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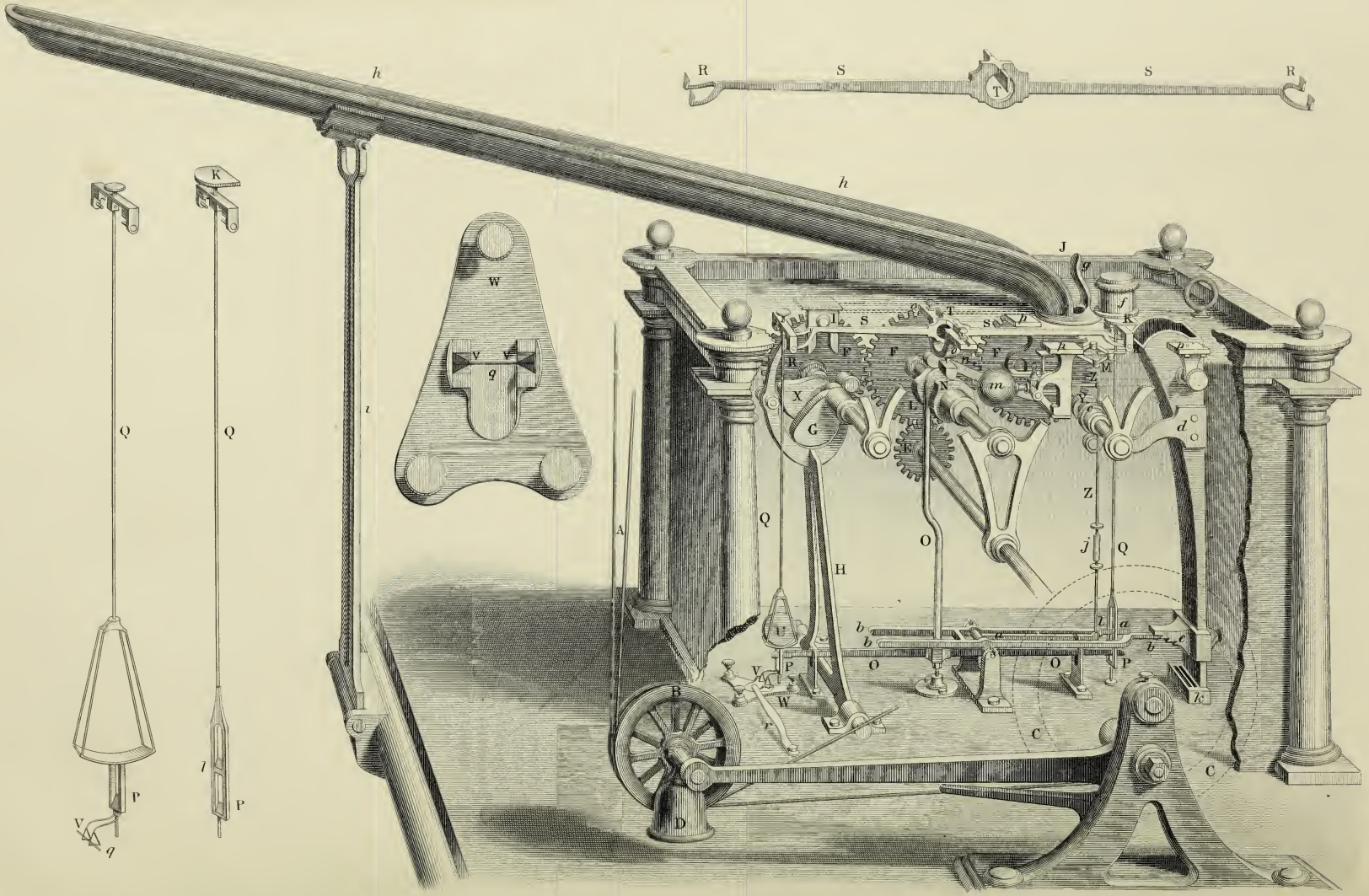

E. S. Gibson del.

J. W. Lowry, Sculp.

COTTON'S PATENT AUTOMATON BALANCE.

WITH PILCHER'S IMPROVEMENTS.

A

TREATISE ON COINING.

BY

GEORGE F. ANSELL,

OF THE ROYAL MINT.

FROM THE APPENDIX TO THE NEW EDITION

OF

"TOMLINSON'S CYCLOPÆDIA OF ARTS, MANUFACTURES," &c.

LONDON:

JAMES S. VIRTUE, CITY ROAD AND IVY LANE.

1862.

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TO

THOMAS GRAHAM, ESQ., F.R.S.,

MASTER OF THE MINT, ETC. ETC.

SIR,

I have written a short article for "Tomlinson's Cyclopædia," for the purpose of explaining (as far as the limited space at my disposal would allow) some of the details of the process of Coining, and by permission of Mr. Tomlinson I am allowed to have a few copies of that article printed separately for private circulation.

I take advantage of this opportunity to acknowledge most gratefully that the information I have been so fortunate as to obtain on the subject of Coining has been gained in consequence of the opportunities you have afforded me in my position in the Royal Mint. With heartfelt thanks for the privileges you have accorded me, and for the support you have given me,

I beg to remain, Sir,

Your most faithful servant,

GEO. F. ANSELL.

ROYAL MINT, *August*, 1862.

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A

TREATISE ON COINING.

FROM THE APPENDIX TO THE NEW EDITION

OF

"TOMLINSON'S CYCLOPÆDIA OF ARTS, MANUFACTURES, MINING, &c."

COINING is the term applied to the processes employed in the manufacture of money. In this article it is proposed to describe the present mode of manufacture; but it may be as well to state, that in remote periods money was made by cutting out a piece of metal somewhat of the form of the intended coin, and imparting the device to it by the blow of a sledge-hammer. For this purpose the blank piece of metal was laid upon a die, say the obverse, fixed into a block of wood or stone, supposed to have been so large as to absorb the vibration caused by the blow, and to a great extent prevent the quivering which would naturally arise, and cause unsteadiness. The workman then took the other die, say the reverse, and passing it through a folded sheet of lead, in order to avoid the shock to the hand, he placed the engraved part on the blank, while resting on the lower die, and held it firmly while another workman struck it with a sledge hammer. At a later period the upper die was held in a twisted hazel stick. After each blow the dies were what is technically termed locked together, that is, the lower and upper dies were made to fit into the partly formed coin, so that neither die could turn without turning the whole mass, and then a second or third blow was given, till the coin was completed. An improvement on this method was effected by fitting the two dies into rods of iron, which may be represented as a pair of tongs; the flat parts which are used to take a coal, would then be the place occupied by the dies. This plan saved the operator some risk of bruised fingers, but the process was essentially the same as the original one; and to money produced from both plans was applied the term *hammered* money, in contradistinction to *milled* money, that is, money which was made from blanks obtained from fillets which had been rolled in a very rough kind of rolling mill, driven by horse power—the germ from which sprang the present machinery. The processes now used are as elaborate as the old methods were simple; but considering the requirements of the present day, and the enormous quantity of money produced, it must not be expected that our coins will, for depth of engraving, bear comparison with those of the Romans, who, though succeeding in producing finished works of art, seem to have forgotten the wear and tear to which they would be subjected, and so left them, as a rule, free from a protecting edge; hence they would lose their image and superscription at a far earlier date from their birth or manufacture than would the well-made coins of the present period.

When it is desired to coin gold, the authorities of the Bank of England give notice to the Master of the Mint, and a day is fixed on which importation shall commence, and on that day the Bank sends to the Mint, in a waggon, say 200 ingots of gold, each weighing about 180 ounces, previously assayed.[1] Upon

(1) Gold is sent to the Mint to be coined under the authority of the Act of Parliament, 18 Charles II., cap. 5.

the arrival of these ingots at the Mint, they are taken to No. 2 assay office, where, in the presence of an officer from the Bank of England, a small piece is cut from each ingot and hammered out into a kind of strip. This piece is then put into a paper marked with a letter which corresponds with the mark or letter on the individual ingot from which it was taken. This having been effected for each ingot, the pieces are forwarded with their respective ingots to the Mint Office, where their weight is determined and compared with that charged by the Bank of England. The pieces which have been hammered out and placed in a marked packet, are called the "assay pieces." The assay pieces are sent to the resident assayer in the Mint, who estimates and reports to the Master the amount of pure gold in each ingot. The report of the resident assayer is then submitted to the Bank authorities, and if they find it to agree with their own assayer's report, the ingots are retained for operations in the Mint. When it is desired to get the ingots of gold into a form fit for coining, they have to be alloyed with copper or with fine gold, so as to bring them to standard or crown gold, which consists of 22 parts of pure gold and 2 parts of alloy, or 91·66 per cent. of pure gold and 8·33 per cent. of copper in 100 parts. Copper is usually employed because it is cheaper, and forms a harder alloy than silver.

Supposing there are 100 ingots, having a total weight of 18,000 oz., and by assay it has been found that these contain 17,900 oz. of pure gold, it is required to bring these to the standard fixed by law. A rule of three sum tells how much alloy or how much gold is to be added. So, if 22 parts of pure gold require 2 parts of alloy, how much alloy will 17,900 parts require? The fourth term of the following proportion, viz., as 22 : 2 :: 17900 : 1627·027, will show how much is to be added; but since there are already 100 oz. of alloy present, as indicated by the fact that 18,000 oz. contain within themselves only 17,900 oz. of pure gold, it is only necessary to add the excess required, viz., 1527·027, so that these 100 ingots will produce 19527·027 oz. of standard gold. Had the ingots been found to contain more alloy than is required, it would have been necessary to add so much pure gold as would have rendered the whole standard. The proportions of the metals having been determined, the whole mass is divided so as to make about 1,200 oz. of gold and alloy for each melting pot. In practice it is customary to take the estimated amount of gold in a given number of ingots and add so much alloy, or so much pure gold, as shall bring those ingots to standard, the whole weight being generally about 1,200 oz.; this is called *potting* the ingots. Ingots are invariably melted, and cast into bars for sovereigns.

Fig. 1[1] represents the arrangements for melting the ingots with their alloy, for producing standard gold. In the Mint there are seven furnaces, each furnace, A, is 12 inches square and 24 inches deep to the top of the bars, which are seen at the ashpit, B. The pot, C, is made of a mixture of Stourbridge clay and plumbago, hence called a *plumbago pot*; it is 9¼ inches deep, and 7 inches across at the top inside. The pot is placed in the furnace on a *bottom* which stands upon the two centre bars. The bottom is intended to shelter the base of the pot C from cold air. The pot is then covered by its muffle and lid, and surrounded by fuel, which, as it burns up, warms and then heats the pot to redness, but so gradually that there is no great risk of breaking the pot. When the pot has become of a full red heat, the ingots are carefully placed in it, and the alloy is added by means of the funnel I: the pot is then covered up, and allowed to remain till the whole mass of metal has liquefied. The foreman then stirs it with a rod made of the same substance as the pot, and allows it to remain till the fluid mass has reached a peculiar temperature, known by experience as that at which the metal, when poured into a mould, forms

Fig. 1. GOLD MELTING.

the most solid and workable bar. This temperature having been gained, the two outside bars at B are removed, the ashpit is then covered, to protect the men's feet, and the firing poked out. The lid and muffle are next removed from the pot, and the pot lifted by an assistant from the furnace by the crane D. The foreman then conveys the pot, C, by means of a pair of tongs which clasp it, to the frame of moulds, when an assistant brings forward a loop of iron, suspended by a chain and cord from the roof of the building, and passing the loop of iron over a button on the end of the lower clamp of the tongs, as shown at E F, supports the weight of the pot by the cord, as indicated at G. Previously to the melting, pieces of charcoal were placed at the bottom of the pot for the purpose of reducing any oxide that may be present in the alloy. When the metal is fused, this charcoal is brought to the surface by stirring, and as it rises

(1) In the engravings which illustrate this article, the initial letters used to indicate the different parts are made to take their places in accordance with the order in which the various parts of the machine under description come into play, so that by tracing out the alphabet in any figure, the reader will see the consecutive action of the parts of the machine he is studying.

through the fluid alloy, reduces the oxide of copper, and remains on the surface to protect the alloy from the action of atmospheric oxygen. In order to prevent it from falling into the moulds the assistant holds a piece of stick at the mouth of the pot, thus allowing the gold to pass, but stopping the charcoal. The foreman in the case of gold judges almost wholly by the eye, but in the case of silver by the ear, as to when the moulds are filled. The metal poured from each pot forms four bars. The moulds, H, are made of iron, cast into such a form that each piece viewed from the top has the form of the letter T, so that three pieces placed together form two moulds; the whole of the set is held in its position by cross-bars, L, which fit into notches cut in the main frame, M, where will be seen two powerful screws by which the moulds are forced tightly together after the cross-bars, L, are fixed. J represents the pots placed so as to be kept dry and ready for use; K, the wheels and tram on which the frame of moulds runs. The whole of the set of moulds having been filled, the screws at M are loosened, the bars L removed, and the parts of the several moulds removed, so that the bar in each mould is exposed to view. The workman takes each bar as it is exposed by a pair of tongs, and plunges it into a cistern of cold water to ensure rapid cooling, and then places it on a bench, where the bars produced from each pot are separated and marked with a number, to indicate the pot from which they were poured, and the entire set with letters, to indicate the day on which the

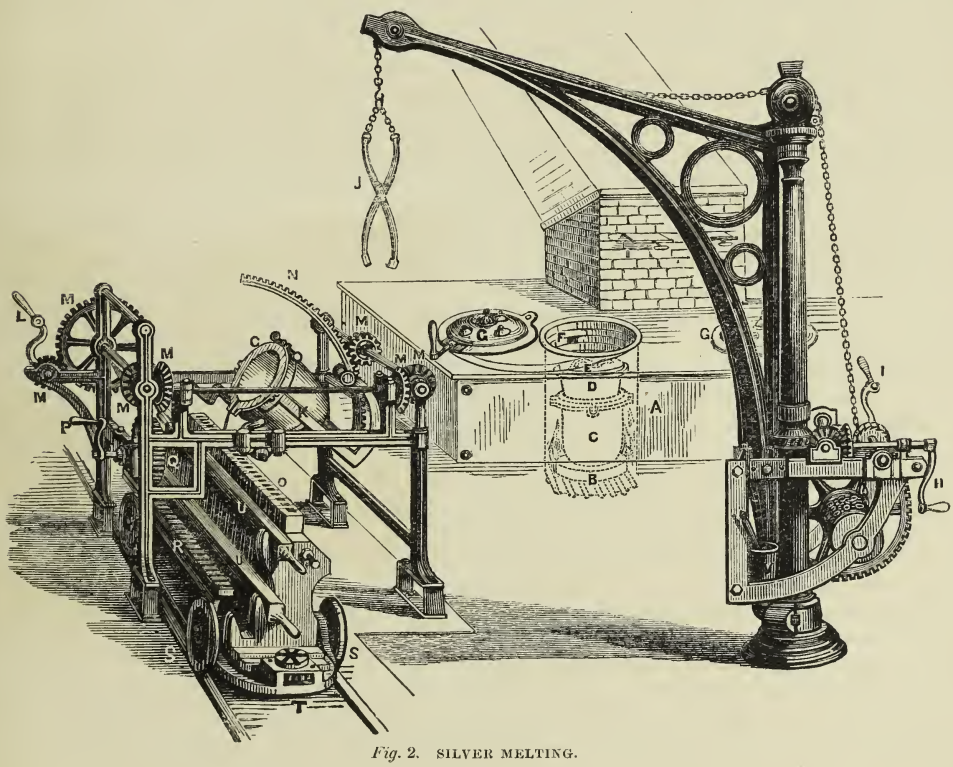


Fig. 2. SILVER MELTING.

melting took place. After these distinctive marks have been placed on the bars, two assay pieces are taken from the bars from each pot.

As silver melting is slightly different in some of its details, it will be well to describe it here. In Fig. 2 A indicates the furnace with the front removed, to exhibit the internal arrangements. The furnace is circular, and is 21·5 inches across, and 31 inches deep. The bars, which are represented by dotted lines, are removable at will. The *bottom*, B, stands on the centre bars, just as in the case of gold melting: it is filled with coke dust, which retains any silver issuing from a small accidental crack or pin-hole in the pot, and also offers a non-conducting medium for the pot, C, to rest upon, it being necessary to avoid the abstraction of heat by the current of air against the base of the pot. A muffle, D, is placed on the pot, and upon this muffle the lid, E, rests. The pot is circular, and provided with a lip, to facilitate the pouring of the metal; it is made of wrought iron, 12 inches across at the top, and 15 inches deep, and when melting for florins is charged with 4,800 ounces of silver. As in the case of gold so with silver, the metal is alloyed with copper. Standard silver being composed of 222 parts of pure silver, and 18 parts of copper in 240 parts; or 92·50 parts of silver, and 7·50 of copper in 100 parts. The calculations based on the assays from ingots, are just the same as in the case of gold. The ingots are put into the pot, and the lid is placed on the muffle (which is intended to prevent metal from falling over

the top of the pot during the process of fusion, as sometimes might happen when *scissel*[1] is melted), and the furnace is then closed, so that the air enters through the bars, and passes into the chimney through the flue F. The lid of the furnace, G, is provided with peep holes, by which the temperature can be regulated at will, while they also admit of a survey of the state of the furnace. When the fusion is complete, and carried so far as to raise the fluid metal to the necessary temperature, the bars of the furnace are removed, with the exception of those which support the pot, and the fuel is poked out, because the pot at this temperature is so soft that it would be *torn* if it were pulled through the fuel. The lid and muffle are next taken off by tongs, and the crane is swung round by the handle, H, till its tongs are brought over the furnace, when, by working the handle I, the tongs, J, are lowered till they come to the pot; the foreman then makes them seize the pot, and by a signal gives his order for the raising of the pot from the furnace. Pieces of fuel and iron scaling are knocked off from the pot by the foreman, with a brush kept in a crucible of water, indicated by V, at the foot of the crane. The crane is then swung round by H, till the pot is over the cradle K, when it is lowered and secured in the cradle by the screw, shown at C′. The frame of moulds is now run under the lip of the pot, and the foreman, by means of the handle L, which will be seen to communicate with the wheels M, and the rack N, tilts the pot so that the fluid metal may pour in a good stream into one of the moulds O, until, by the sound, he judges it to be full; he then lowers the pot, while his assistant, who is also watching the filling of the moulds, turns the handle P, which, by the wheel Q fitting into the rack R, moves forward the frame of moulds so far as to allow another mould to come beneath the lip of the pot, to be filled as before. The fluid silver in the melting-pot is covered with charcoal, for the same reason as explained in gold melting, and this is kept back by means of a large piece of charcoal laid at the mouth of the melting-pot. The frame of moulds runs on wheels S, and at T is provided with a rack and pinion, by which the moulds may be moved farther from or nearer to the lip of the pot, which, as it is tilted, is continually altering its relative position to the mouth of the moulds, and would, were it not for this arrangement, pour its metal outside of, or upon the moulds, instead of into them. The moulds are formed of T pieces, in the same manner as the moulds for gold, and are secured in their position by the same method, the cross-bars being shown at U. The bars having been taken from the moulds are cooled in water, and distinctively marked, as in the case of gold. Assay pieces are cut from them, but in the case of silver three assays are taken from the bars produced from each pot.

The bars for different denominations of coins are proportioned in their width so as to admit of two rows of blanks being cut from the fillets produced from them. The following statement gives the whole facts concerning bars for each coin, as used in the Royal Mint. It would be well to produce bars of a uniform thickness of 0·50 inch, as such bars may be cast solid, and when cast produce better fillets with half the rolling without the cost of annealing.

STATEMENT OF PARTICULARS AS REGARDS BARS USED FOR COINING.

Metal.	Denomination of intended coin.	Length.	Breadth.	Thickness.	Average Weight.
		Inches.	Inches.	Inches.	Troy oz.
Gold ...	Sovereign	24	1·375	1·000	320
	Half Sovereign .	24	1·125	1·000	250
Silver ...	Crown	22	2·750	1·000	300
	Half Crown	22	2·500	1·000	240
	Florin	21	2·125	1·000	220
	Shilling	21	1·437	1·000	150
	Sixpence	21	1·125	1·000	120
	Fourpence	21	0·875	1·000	96
	Threepence	21	0·875	1·000	96
Bronze .	Penny	24	2·500	0·375	100
	Halfpenny	24	3·000	0·375	117
	Farthing	24	3·000	0·375	117

Crowns, half-crowns, and fourpences are no longer coined. The last crowns were coined in 1847, when 8,000 of those celebrated coins from the dies of William Wyon were struck, the moneyers being paid at the rate of 10·50 pence per pound weight for coining them.

The assay pieces, when cut from the bars, are placed in divisions of a tray going from left to right, so that there can be no mistake as to the number of the pot from which the metal comes; each assay piece is then placed in a small envelope, marked with a distinctive mark, to characterise the pot from which it came. The assay pieces are sent in equal numbers to the two non-resident assayers, who determine, irrespectively of each other, the amount of gold found in each piece. Suppose we trace one assay piece, and imagine that 120 are undergoing the same process at the same time. The assay piece is flattened out into a kind of riband, and from it three pieces are cut, each weighing half a gramme. Each piece of this weight takes the name of a *thousand*, and is represented by the figures 1,000; but of course it may be called a pound, or a ton, or any other denomination. Each piece is wrapped in paper, with three times its weight of silver in two pieces, both metals being of the same thickness. The parcels, as they may now be called, are ready for the next process, and are arranged in their proper places from left to right, in the divisions of a tray, and taken to the assaying furnace. In the assaying furnace is placed a Payen[1] muffle, or kind of oven, perforated at places so as to allow a limited amount of atmospheric air to pass from the interior through its sides into the furnace. The muffle is surrounded with fuel, so that it is kept at a good (almost white) heat. On the floor of the muffle is sprinkled some bone ash (obtained by burning bones to whiteness), and on this bone ash is placed a set of 40 cupels, or little cups, made of compressed bone ash, and about as big as a florin, and so deep as to hold about half a teaspoonful of water. When the cupels have been in the muffle long enough to become

(1) This word is explained at page 18.

(1) That is, made by Payen, of Paris.

red hot, a piece of lead, of about nine times the weight of the gold to be assayed, is put into each cupel, taking care not to let any lead fall over, or it would destroy the muffle. So soon as the lead has melted, the paper parcels containing the gold and the silver are placed one in each cupel of melted lead. In a short time the gold and silver melt together, and, as it were, dissolve in the lead; then a kind of circulation of the fluid metallic mixture is observed to take place, and during this circulation, the lead, as it is presented to the surface, meets with the oxygen of the atmosphere, and combining with it, forms oxide of lead, which at that temperature is fluid, and drains into the substance of the cupel, carrying with it the copper and other impurities contained originally in the gold, leaving in the cupel a button which contains all the pure gold and the silver. The cupellation occupies about ten minutes, and at the end of that time the little mass of fused metal is observed to brighten up, the signal by which the assayer knows that the process is finished, and he withdraws the cupels one by one, tilting the fluid globule on one side that it may incorporate with it any small globule which may chance to be upon the side of the cupel. Some assayers close the doorway of their muffles, as the time of the brightening up of the assay approaches, to avoid the access of the atmosphere till the buttons have become solid, because the button of metal (by its silver) absorbs oxygen; and giving off this oxygen at the moment of solidification, spurts or opens, leaving the button hollow or ragged. This precaution is not thought necessary by all assayers. The button is taken from the cupel as soon as it has been detached, either by dropping a little water on to it, or by allowing it to cool spontaneously, and it is then hammered out into a strip and annealed. It is next rolled into a ribbon or fillet and again annealed; after which, it is curled up into the form of a letter S. Some prefer to roll the piece into a kind of cushion, but in such case it is more difficult to remove all the silver; the proper plan is to expose as large a surface as possible to the action of the acid in the next operation.

The S-shaped fillet is put into a flask of nitric acid of specific gravity 1·23, and the flask is placed in a little cup of brass, which stands over a small gas-burner, while the neck of the flask enters a kind of flue through which a current of air is continually passing into the chimney of the furnace. The flask being placed in its position the gas is lighted, and a gentle heat applied, when the nitric acid dissolves out the silver from the S-shaped fillet, and is known to have done its work when red fumes cease to be evolved. The acid is then poured off, and the remaining sponge of metal is washed with distilled water, and boiled with concentrated nitric acid, which removes the remainder of the silver. The sponge of gold is now washed with water, to remove the nitrate of silver, and is then heated to redness in a capsule to render it tough, for in its spongy state it is so rotten that it will not bear to be touched; and although it remains spongy, it is toughened by being heated to redness. It is now called a *cornet*. This spongy state is a consequence of the addition of silver, the presence of which, and its subsequent removal, produces a separation of the particles of the gold. The gold is thus formed into a kind of network or sponge, so that the acid can get at every part of it, and remove any metal which is soluble in the acid. Diluted acid is used first, because if there be any lead left it is dissolved out, and because the action of the strong acid is so violent, that part of it would probably be carried out from the flask. Nitric acid, when boiling, is liable to form bubbles of gas, which expanding, give rise to what is called *bumping;* hence it is usual to put a charred pea into the flask, and this, floating on the surface, causes a more even flow of vapour and gases, and so prevents bumping. It is probable that it determines the boiling at one particular temperature, for it is found that water, if it be floated in a fluid of a higher boiling point than itself, may be raised considerably above its ordinary boiling point, remaining quiescent till disturbed by a rod or point, when it boils. The cornet is next weighed, and as it has been begun under the idea that it was a *thousand* (1,000), all that it weighs short of 1,000 is the alloy which has been removed, the object having been to determine how much pure gold was present in the alloy. There is, however, a source of error in the process which requires to be explained.

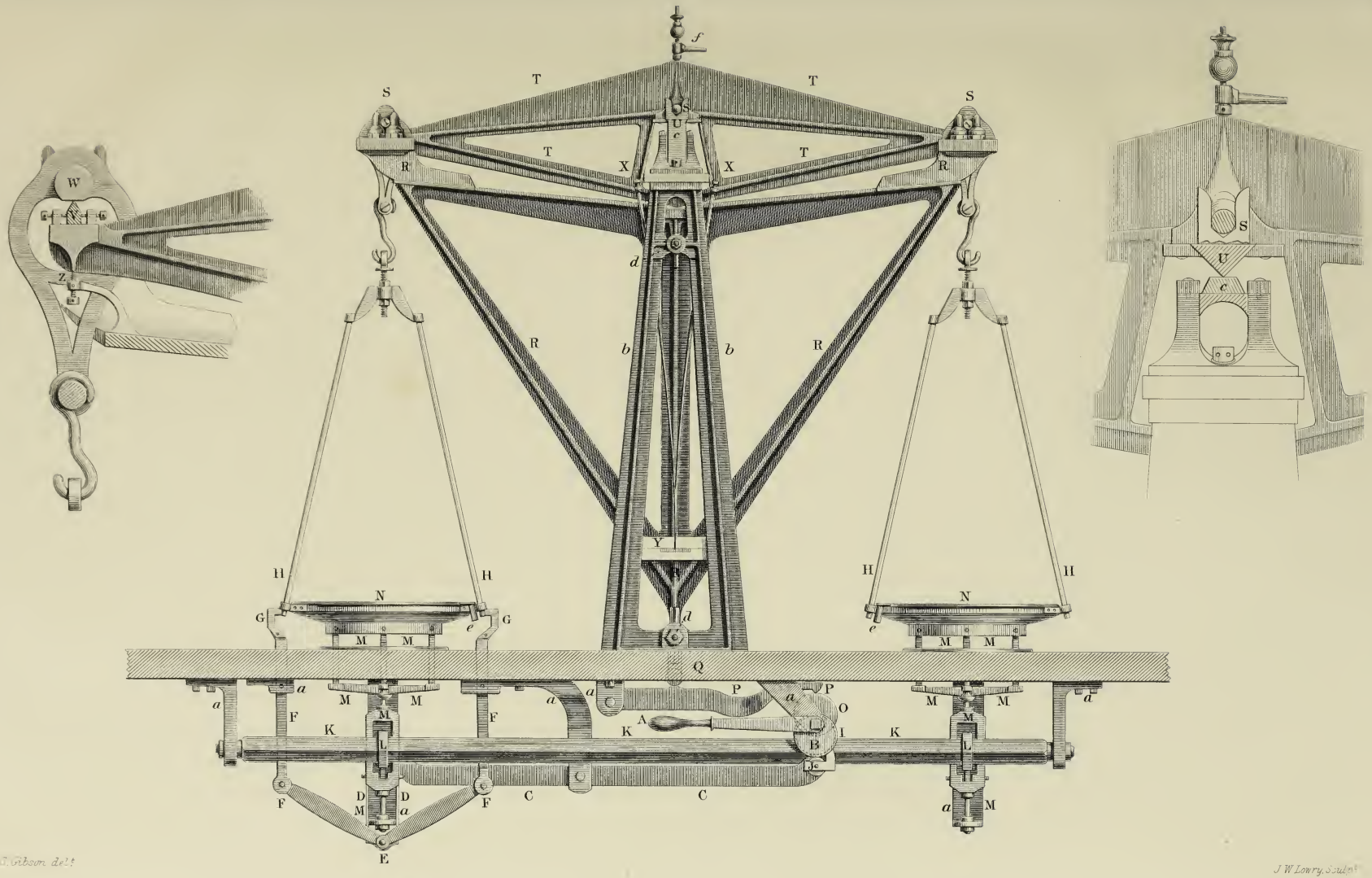
It is found to be practically impossible to remove every trace of silver from the cornet; it is therefore necessary to make an allowance, the amount of which is determined by a *proof*. The proof consists of a mixture of gold and silver of known proportions, so that if all the silver be removed from a thousand (1,000), the remaining cornet should weigh exactly 916·6. Four of these proofs are worked with each batch of assays (a batch being 120 assays), under precisely similar circumstances, every precaution being taken that the four shall be equally distributed over different parts of the furnace, &c. Now suppose that the proofs instead of weighing 916·6, as they would weigh if the whole of the silver were removed, were found each to weigh 916·9; it would be known that 000·3 of silver had been retained, and must be deducted from each of the whole batch of assays. If the assay of coins exceed the limits of from 917·6 to 915·6, they are repeated, as it is assumed that an error has arisen. The convenience of considering the ½ gramme as 1,000 consists in the fact that 1,000 parts of standard gold contain 916·67 of gold and 83·33 of alloy; so that the result being arrived at without any calculation, one source of error is avoided and time is saved.

The assay for silver is not so tedious, as it is finished at the point where it leaves the muffle on the cupel; but up to this point it passes through precisely the same process as the gold. When the assay reports arrive, the Master determines whether the metal has been found within the limits, and if he be satisfied he writes on the assay reports "Passed," and signs the reports. The Deputy Master retains the reports as his

warrant, and then issues his order for the delivery of the bars by the melter to the Mint Office. The bars are weighed at the Mint Office from the melter, and their weight is recorded; they are then passed to the coining department to be converted into coin; but, as the accounts are kept by weight, every set of bars is weighed by the officer who receives them into the rolling room before he gives them to his men to work into fillets. Great attention is now given in the Mint to the construction of balances, because it is necessary for the officer in charge of any department to ascertain the exact amount he gives to his men, and to satisfy the Master that they have returned (to within the limit of one blank of whatever denomination of coin he may be working) the bullion which they received. The balance which is found most serviceable is that made by Mr. S. R. Short, of the firm of De Grave, Short, and Fanner,[1] of St. Martin's-le-Grand, of whose balances it is impossible to speak too highly, since the balance represented in the steel engraving, after months of wear, determines to within 1 grain when charged with 1,200 ounces troy. The mode of proving the accuracy of a balance is to weigh as usual, and having arrived at a just determination of the weight of the matter to be weighed, to change the weights to the pan in which the matter has been weighed, and to place the matter in the pan previously occupied by the weights, so that both are now made dependent from the opposite ends of the beam; if the results be identical with the former results there can be no doubt as to the accuracy of the beam; should there be any variation the balance must be adjusted by minute alterations of the knife-edges at its ends.

The balance used in the rolling room of the Royal Mint is specially adapted for the purpose. Such a balance as already noticed must be accurate, as must also all the balances used in the Mint, but this balance requires an arrangement by which the pans can be released from the beam and held firmly while being loaded. Mr. S. R. Short has been peculiarly happy in effecting this object, as will be seen by reference to the steel engraving, which exhibits a fine illustration of Mr. Short's balance. The raising of the handle A causes the partial revolution of the cam B (represented by dotted lines), and this as it diminishes releases the lever C, which, by the rods D acting on the point E, permits the approach of the joints on the rods F towards the centre. The rods F work on a centre fixed beneath the table on which the balance stands, so that the closing of their one end causes the opening of the other. Thus the claws G recede from the wedges H, upon which they had been fastened, and so release the pan, for the claws act simply as a man's hand would act in fixing the pan while it is being loaded. Immediately upon the opening of the claws another action takes place by the continued movement of the handle A, which causes the cam I to rotate upon the friction roller J, affixed to a lever proceeding from the shaft K, which at L is cut with eccentric bearings, so that by the partial revolution of K, caused by the pressure of I upon J, the series of supports M sink downwards from the pans N, thus obliging the pans with the rods which support them to be suspended from the supports S, which rest on the frame R. So soon as the pans are thus suspended the continued motion of the handle A causes the cam O to permit the falling of the lever P, which at Q supports upon a friction roller the iron framework R. This framework terminates upwards at the points near S in sugar-loaf cones of gun-metal, which are intended to relieve the knife-edges of the beam from the pressure of their planes, while the beam T is out of use, or while it is being loaded, for at these times the knife-edges would become seriously damaged. By the lowering of the frame R the centre knife-edge U is permitted to rest on its plane of steel *c*, which is beautifully bedded on an arch of gun-metal. In fact, the steel plane *c* is secured by wedges exactly shaped to it, but for the sake of illustration these wedges have been replaced in the enlarged portion of the engraving by upright pillars shown against *c*, with screws travelling through them, and intended to fix *c* rigidly in a given position. At the same instant that U comes into rest upon *c*, the knife-edges V at the ends of the beam T receive the planes W, so that the beam has now to support the weight of the matter placed in the scale pans, and at this time is determined the actual weight of whatever that matter may be. The weigher, by an indicator suspended from the beam at X, reads the oscillation of the beam on an ivory plate at Y. At the time of weighing, the beam with its dependents is carried by the four-legged frame of iron *b*. The frame R passes through friction rollers of brass at *d*, which rollers maintain it in its relative position to the beam. The weighing having been determined, the handle A is reversed, and the beam is placed at rest; but the vibration of the machinery in the rolling room causes a continuous chatter of the knife-edges V against the planes W, therefore at each end of the beam a small screw Z is made just to touch the lower edge of the beam when it is at rest. Final adjustments which are very minute may be arranged by *f*; while the box *e* on the pan against G is intended to receive small pieces of lead, which are used to compensate for the loss by the wearing of the pans. The shaft K is supported from the table by *a*. The beam of the balance represented in the steel engraving measures 48·00 inches from knife-edge to knife-edge; that is to say it measures 24·00 inches from the centre knife-edge to the knife-edge at either end. Mr. S. R. Short has made for the rolling room another balance for weighing silver, and as it differs in some important details, it is deemed wise to demonstrate those alterations in Fig. 3, where the supporting frame R will be seen to carry three upright pillars S^1, S^2, S^3. The pillars S^1 and S^3 are represented as being placed on the farther side of the beam, which at those parts is broken away, that the pieces of steel against which the pillars are made to touch may be seen. S^2 touches against one

(1) The Prize Medal was awarded to this firm at the International Exhibition, 1862, for their superior workmanship in balances.



IMPROVED BALANCE (TO WEIGH 2000 OUNCES.)

BY Mr. S. R. SHORT, JUNr.

of these pieces of steel near the centre knife-edge U, and in front of the beam. The pillar S^2 terminates in a point, which passes into an inverted cone, while the point of S^3 is made to pass into an inverted **V**, so that when the beam is raised by these pillars from its centre knife-edge, S^2 obliges it to take a specific position with regard to its distance from the centre of the plane on which its centre knife-edge rests, and S^3 causes it to take a perfectly parallel line. S^1 is simply a plane which rises against a plane and steadies the other end of the beam, which by this arrangement stands as on a tripod, and is, therefore prevented from moving, and in addition has its knife-edge invariably placed upon the same part of the

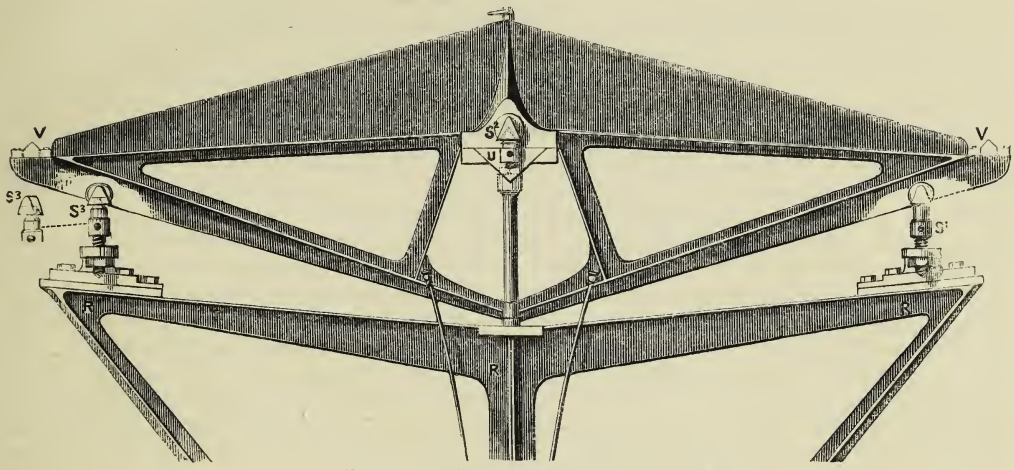


Fig. 3. SHORT'S PLAN FOR LEVELLING A BEAM.

plane at each time of weighing, while the frame R, by its continued lowering, drops the planes with equal accuracy on the end knife-edges, V, thus elegantly fulfilling the essential condition of bringing all the knife-edges into play at the same instant by the most perfectly parallel motion yet invented for this purpose. This is believed to be a new application of the triangle, and in the Mint balance, which is made to weigh 5,000 ounces in each pan, is very perfect in its action, and does away with the necessity for some of the objectionable parts which are represented in the steel engraving of Mr. Short's balance for weighing 2,000 ounces, while it gives the balance a far lighter appearance.

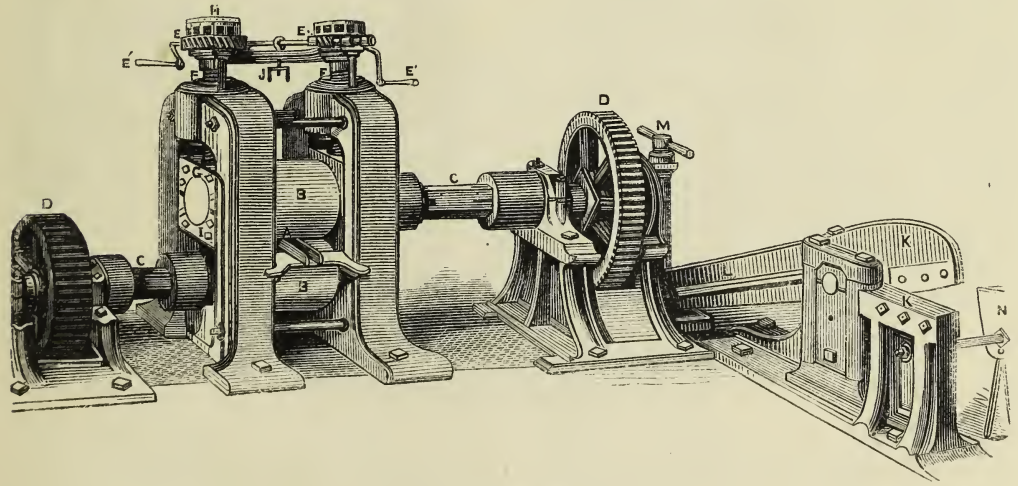


Fig. 4. BREAKING-DOWN MILL.

The sovereign bars having been weighed by the officer, and given by him to his men, are wrought in sets of 20; each set is called a batch, and each bar in the *batch* undergoes precisely the same process. The bar is passed into the opening A of Fig. 4, where it receives a considerable compression, for the rollers B, seizing its end, drag it forward, while they roll back and retard the progress of that part of the bar which is not between the rollers. The result is that the bar is lengthened, but not widened materially, so that length is gained at the expense of the thickness, which is regulated by the distance between the rollers. The rollers are driven by shafts and adjusting couplings, C, which are themselves driven by the

wheels D. The distance between the rollers is determined by the action of the lever E′, which by the endless wheels on its axle at E fitting into geared wheels gives motion to powerful screws shown at F, which terminate in cups on the upper part of the upper brasses of the rollers B, as may be seen at G. The upper brasses are kept always against the ends of these screws by weights which are beneath the mill, but from which levers and rods terminate at the lower part of the upper brasses, at about the position indicated by I, so that the upper roller has motion either upwards or downwards at pleasure, but the motion upwards is arrested by the powerful screws F, and this point once determined by the reading on the scale H, is fixed by the clamp J. The thickness, therefore, of each bar in a batch is determined within certain limits; and when each bar in the batch has been rolled the mill is altered, refixed, and again the rolling goes on till each bar has passed seven times at varying pinches through these rollers. Owing to the wear of the moulds in which the bars are cast, the bars are never of uniform thickness; hence bars of every denomination are passed through the rollers on their edge, so as to reduce them to one uniform thickness, otherwise the fillets resulting would be ragged, and of unequal widths, which defect would cause them to produce blanks out of *remedy* as to weight. The rollers are set face to face; the graduated scale H is then set at zero; if then the rollers be separated until there is a separation of 1·00 inch between them, the scale H will indicate 50; if, therefore, it be desired to read a higher figure, part of another revolution must be performed, say causing the scale to read 31·50 of another revolution, the rollers will be so far apart that sovereign bars which pass through them will, allowing for the expansion after compression, be found to be exactly 1·375 inches wide.

If now these bars be rolled on their sides the mill must be turned down till the scale reads 45, when if the bars be passed through they will measure as under for width and thickness at each successive pinch. A *spring pinch* means the passing the bar once more through the mill without altering the distance between the rollers.

A sovereign bar passed through the rolling mill—	Becomes a fillet or riband— Inches wide.	Inches thick.
At 45·00	1·450	0·775
„ 35·00	1·540	0·610
„ 26·00	1·610	1·460
„ 19·00	1·665	0·335
„ 14·00	1·696	0·250
„ 10·50	1·712	0·194
„ 8·50	1·765	0·148
„ 7·00	1·778	0·129
„ 1st Spring pinch.	1·778	0·127
„ 2nd „ „	1·778	0·120
„ 3rd „ „	1·779	0·118
„ 4th „ „	1·781	0·117

When the bars have passed through the rollers at 10·50 they have become of great hardness, and of considerable length, say 6 or 8 feet. They are then taken to the shears K, where their hollow ends[1] are cut off, and the bars cut into lengths of 18 inches. The shears may be regarded as large scissors driven by a drum on the same shaft that carries the driving wheel for D. The drum is eccentric, so that at each revolution the shears are caused to open and shut. The bar being placed between the jaws K, the long end L of the shears is raised by the drum, and the piece is cut off. The shears may be closed and suspended when out of use by a hook on the end of the screw worked by the lever M. The length of a bar to be cut off is determined by the gauge shown at N.

The sheared bars are placed in copper tubes, the tops of which are luted on with clay. It is imperative that the copper tubes be made without solder, because this fuses at a temperature below that which is required to anneal the gold; if present it would run down upon the hot gold, and cause it to fuse and alloy with the solder, thus spoiling the work and entailing expense upon the coiner. The tubes which are used in the Royal Mint are made by Messrs. Benhams and Froud, of Chandos Street, Strand, who, after considerable pains, arrived at a method of making the tubes in such a manner as to satisfy entirely the require-

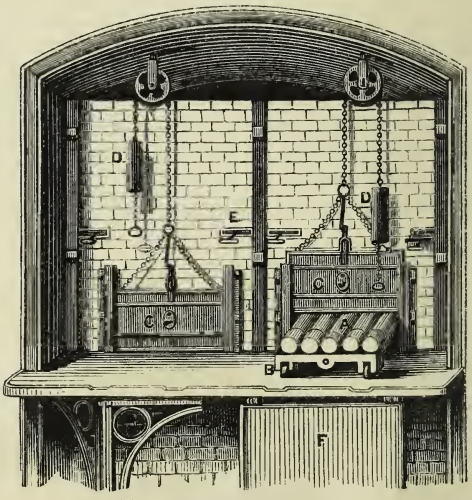


Fig. 5 ANNEALING FURNACE.

ments of the Mint. The tubes A are placed on an iron carriage B, which is then run into the furnace, as shown in Fig. 5. The door of the furnace, C, is closed by raising the counterpoise D; the heat of the furnace is regulated by the damper E. The apron F is sometimes of use in annealing very long silver bars. After remaining in this furnace for twenty minutes, the carriage is withdrawn, and the tubes, taken with tongs, are plunged into cold water, to cool the gold as rapidly as possible. The rapid cooling of gold and silver gives to each metal a peculiar character, which is of value in the after processes, and prevents the access of the atmosphere, which, in prolonged cooling, would cause the oxida-

(1) Hollow ends are caused by the contraction of the metal at the time of solidification, and are invariably at the top of the bars.

tion and consequent removal of so much copper that the alloyed metal would become too rich in gold for circulation. The annealing of metals is effected not so much by the continued heat, as by the slow cooling; it is therefore wise to raise the metal to its full heat as rapidly as possible, and then to arrange matters that it may cool very slowly. This method does not hold good in the case of the precious metals and of copper, for they become, under such treatment, so soft and malleable as to stick to the machinery, and so to cause considerable trouble and loss. After annealing, the bars, which are now called *fillets*, go again to the breaking-down mill, where they are passed through with the scale indicating 8·50, then at 7·00, and after this are submitted to the rollers without altering the scale at all; so that what are called *spring pinches* are given, with the intention of effecting the reduction of the fillet to one uniform thickness, for the breaking down and subsequent rolling has caused the fillets to become much thicker in their middle than at their sides. The spring pinches reduce this, while at the same time they diminish the elasticity of the metal, and fit it for the other mills. It will be seen by reference to the above table, that the widening of the fillets is very trifling; but width may be gained to any desired extent, at the will of the workman, if the bars be submitted to a heavy pinch instead of a series of light ones. The fillet having been submitted to the fourth spring pinch, is gauged on its side by a steel instrument, of which Fig. 6 is a representation. It is a hollow wedge, which is graduated to the thousandth of an inch. Supposing that the open-

Fig. 6. SMALL GAUGE.

ing from A to B were extended until it were one inch wide at A, the space would be divided between it and B into 1,000 parts, and then every fillet passed into this opening would stop at a given point, say, for instance, at ·140; such being the case, every part of the same fillet should be arrested at precisely the same point. The fillets are reduced till they measure 117 on this gauge, and are consequently 0·117 inches thick. They are then passed to the next mill, where they receive four light pinches, and then to a third mill, where they receive two more very light pinches, and by means of these six pinches are reduced in thickness to 0·075 inches. They then pass to another mill, still finer than any of the preceding, and here are submitted to four very light pinches, by which they are reduced to 0·058 inches, and are finally finished at the sixth or gauging mill, where they receive three pinches, and are then 0·053 inches thick by 1·829 inches wide.

The gauging mill is of different construction to the other mills, as may be seen by reference to Fig. 7,

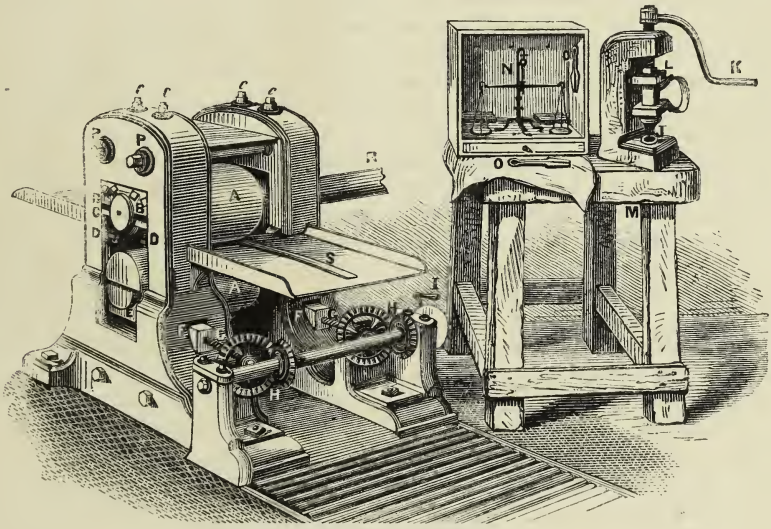


Fig. 7. GAUGE MILL.

where the rollers A are seen in the act of reducing a fillet. The upper roller is fixed in brasses loosely clamped together; the upper brass, B, being firmly bolted to the main frame of the mill by the screws *c*, while the lower one C, which carries the weight of the roller when it is running empty, is supported by spiral springs shown at D. The lower roller rests on a brass, E, which rests on a wedge shown at F; the brass being cut to fit the wedge, so that it may become, as it were, a solid mass, irrespective of any motion given to the wedge. By this mode of adjusting, a difference of the 0·001 of an inch may be made with ease between the distance of the rollers, and, consequently, in the thickness of fillets which may pass between them. The wedge F is moved forward and backward by the screw G, which itself has motion from the gear work H, by the handle I. Directly a fillet is passed into the rollers, the upper roller is forced against its upper brasses, and further upward motion becomes impossible. The elasticity

of the metal of the roller causes irregularities in the thickness of the fillets which pass from the rollers, causing much trouble and some expense; therefore it is proposed to support the upper roller by a similar arrangement to that which affects the lower roller, and to keep it rigidly against the upper brass, but with just so much pressure as its own weight would induce were circumstances reversed; and by these means to relieve the fillet from the weight of the roller, which has an undue influence on each end of the fillet. The gauger of fillets requires other tests besides that of the thickness of the edge of the fillet, so he punches out a blank from an occasional fillet, by a hand press, the cutter of which is shown at J, Fig. 7, worked by the handle K, through the screw L. The blank falls through the bolster of the cutter and is caught at M, and is then weighed in the hand scales, N, against a standard weight, from which it must not vary more than 0·50 grain. O, Fig. 7, is the gauge actually used by the workman; Fig. 6 represents the standard gauge used only by the officer in charge to check the work at its various stages. He has in addition a gauge of great accuracy, by which to measure the fillets at any point, as to width and thickness. This gauge will be more intelligible by reference to Fig. 8. A is the

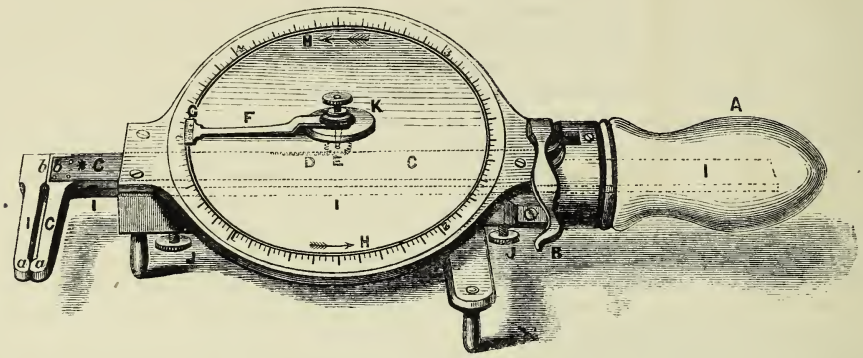


Fig. 8. STANDARD GAUGE.

handle, which is hollow; B is a lever attached to the flat rod of copper C, which at D is cut with a rack, into which a pinion, E, is made to work. The pinion E works on a shaft, the upper end of which carries a hand, F, provided with a vernier, G. If now the handle A be firmly held by the hand, while the thumb be made to press the lever B towards the end of the handle, the rod C is set in motion and causes the hand G to travel in the direction of H. The rod C rests on another rod, I, made of steel, and so long as to pass into the handle of the instrument. The ends of the rods C and I are fitted at *b* with steel shoulders, and are then continued, as represented, to *a*. If it be desired to measure the thickness of a fillet, the points *a a* and *b b* are caused to open by pressure applied to B, and the fillet is placed between the points *a*, when a spring fixed in the box K brings back the rod C as soon as B is gently released, and encloses the fillet. The separation of the points *a*, by the fillet, causes the hand or indicator G to stand at a point from zero, which is then read. The scale is divided into 500 parts; and if the points be opened 0·50 inch, the hand makes one revolution; so that the ·001 of an inch is gained by one reading. But each 0·001 is subdivided by the vernier into ten, so that a ten-thousandth part of an inch is read without trouble. To measure the diameter of a blank coin, or the width of a fillet, it must be placed between the points *b*; but since the extreme opening of this gauge is 0·50 inch, it is necessary, if it be desired to measure a larger diameter, to press back the lever B till the zero of the vernier G reaches 0·500 on the scale H, and hold it there while a clamp is made fast at the spot indicated by the star (*) to prevent the motion of C without I. When the clamp is fixed, the rod I must be drawn out till the zero of the vernier reaches the zero of the scale H, when the screws J must be tightened, to retain I in its new position, with half an inch permanent opening between the points *b* and between the points *a*. In a new measurement, this permanent 0·500 must be added to the reading. This arrangement admits of measuring up to 3·5000 inches, to which limit the gauge is extremely accurate. The instrument was made by Mr. C. Becker, of 30, Strand.

The fillets are weighed from the rolling room to the drag room, where they are finally adjusted; for even with the energy, discretion, and skill used by Mr. Robert A. Hill, the fillets cannot be obtained of uniform thickness. In the drag room the fillets are taken to the small shears, Fig. 9, by which one end of each fillet is trimmed so as to render it square. The plates A are fixed to the head of a T-shaped lever, the pillar of which is caused to oscillate by a cam under the floor. The plates A shut against a face of steel fixed to a block and held by the screws shown at B; if therefore the end of the fillet be passed between the plate A and the face of B, each oscillation causes the cutting off of so much as protrudes, the pieces cut off falling into the box C. D forms part of a chain, by which the shears are thrown out of motion. The fillets having been trimmed so as to render their ends square, are next passed to the extent of about two inches be-

tween the rollers of a flatting mill, shown in Fig. 10, which reduce that part of the fillet to about two-thirds its thickness. A A are a pair of small rollers, the upper one of which is cut with three flat faces, so that it has three rounding and three flat surfaces; hence, when both rollers are revolving,

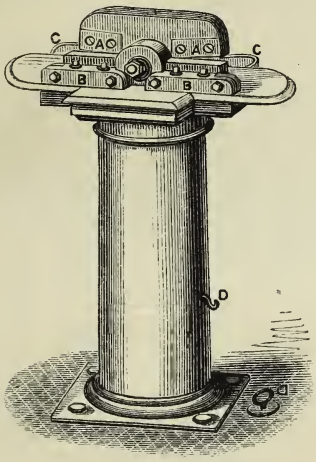


Fig. 9. SMALL SHEARS.

there are spaces with openings between them; but when the rounding faces come down, those openings are much narrowed, so that every fillet which is between them becomes flattened to just such an extent as may be deemed necessary. The rollers travel in opposite directions, so as to cause the expulsion of

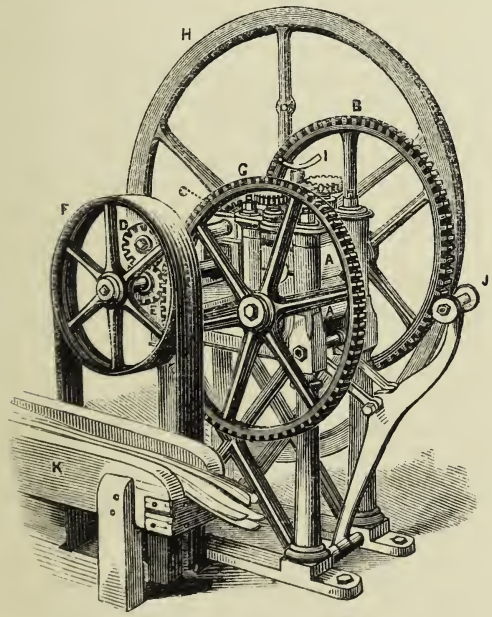


Fig. 10. FLATTING MILL.

a fillet placed between them. The reverse motion is gained as follows:—The upper roller is driven by B, which receives its motion from the little pinion C, carried on the shaft which also supports D. D reverses the motion of E which is driven from the drum F. E also drives G, which gives motion to the lower roller. The fly-wheel H is carried at the other end of the shaft which carries F and E. The fillets are rested on J while being flatted, and are, after flatting, placed in the trough K, from which they are taken to a rolling mill in the drag room, of precisely the same construction as that exhibited at Fig. 7, to be passed twice through at equal pinches, with a view to render them still more accurate than they were when leaving the rolling room. The rolling mill in the drag room is provided with steel rollers. Steel rollers are of somewhat recent invention, and seem to have received a high character from those whose opinion may be modified by further experiments more accurately made. It is thought that they are not worth their extra cost, as at present fitted; but that their usefulness will be more fully developed when they shall have been fitted with the arrangements proposed for the gauging mills before explained. After these alterations have been made, it is fairly to be questioned if steel rollers will, under circumstances every way similar, produce better work than is produced by the ordinary chilled iron rollers; in other words, it is believed that steel is not a better substance for rollers than chilled cast iron. Those who have to sell, and those who have to use, have, of course, different motives; he who has to use a machine judges calmly, and should not be led away because the invention is new. It is amongst these considerations that one is convinced that steel rollers do not save money; for if they wear longer without getting out of order, they also require longer to put them again in order. Rollers, made from whatsoever substance, cannot reasonably be expected to produce a fillet from every part of which blanks of equal weight can be struck; but if the construction of the mill be altered, the rollers may approach nearer to that perfection which is gained by the draw-bench to which the fillets are taken from the steel rollers.

Fig. 11 represents the *draw-bench*, the name of which is retained, as being in fact its only appropriate one. The thinned end of each fillet is passed into the opening shown at A. The *dog* A′ is then run up till its teeth seize the fillet. The lever is depressed until one of the hooks, O, catches a bar of the circulating chain P, which in its onward motion drags the dog, and causes it to bite the fillet and *draw* it through the opening at which it has been entered. P gets its motion from a notched cam, the axle of which is shown at Q. There are two distinct chains to each draw-bench, and there are two distinct draw-benches, so that one description does for both double ones. R is a cogged wheel, the shaft of which, Q, carries two notched drums, and each drum gives motion to a chain, so that both chains travel at the same pace. R is set in motion by the pinion S, on the shaft which is driven by the wheel T. T is driven by U, which is on the shaft driven by the strap and drums V. Fig. 12 is a representation of the head of the draw-bench, and in studying this engraving it will be well to refer at the same time to Fig. 11. The dog takes its name from its resemblance to the head of a bull-dog. It consists of a pair

of levers, whose long arms extend beyond the axle-tree of the wheels nearest to O, and whose shortest arms are formed by the passing of the other axle-tree through the lever. The teeth are set at the front of the short arms. The axle-tree near O is fixed to the bars forming O, and runs loosely between the long arms of the lever, so that when O is pulled forcibly it causes the axle-tree to open the long end of the levers, and thereby to close the short end or teeth of the dog, the more rigidly in proportion to the pressure exerted at O. Directly the fillet has passed through the cylinders the dog springs slightly, by the elasticity of the fillet, and

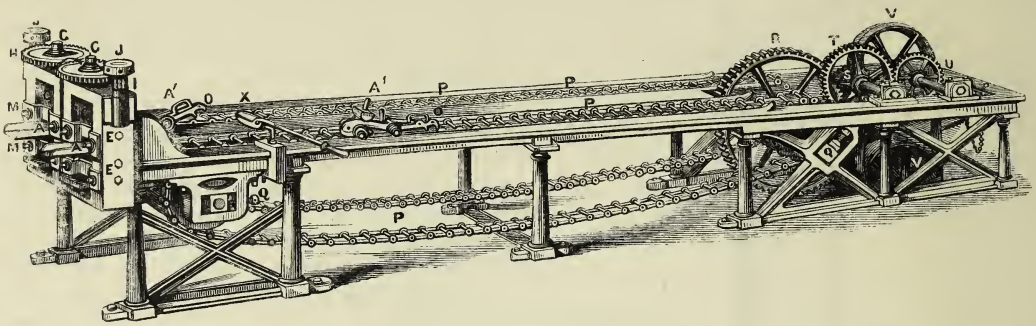


Fig. 11. DRAW-BENCH.

thus releases itself from the chain; at the instant of release the weight over the foremost wheels falls, and by its fall lifts the hooks O so high as to permit their escaping contact with the circulating chain P. The position of the teeth of the dog is shown by A in Fig 12.

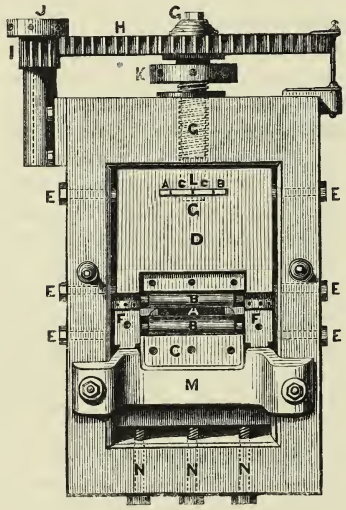


Fig. 12. HEAD OF DRAW-BENCH.

The thinned part of the fillet is just so thin as to admit of its passing easily between the cylinders B until seized by A, but the part which is not thinned comes against the cylinders B, and requires considerable force to drag it between them. The cylinders B do not rotate; in fact, they may be considered as forming part of a solid mass. The lower cylinder is laid on the bed C, and is clamped there by a cheek screwed on to C by three screws, the holes for which are shown on C; the upper cylinder is fixed to the mass D by a precisely similar arrangement. The beds, C D, are held perpendicularly by the screws E; and we may now view the cylinders as secured to, and forming part of, their beds. The distance between the cylinders is regulated by the capstans F, which separate the beds of the cylinders, and so separate the cylinders. The accuracy of this adjustment is all important, because the distance between the cylinders determines the thickness of the fillet which passes between them. The bed D of the upper cylinder is required to be movable at pleasure; it is, therefore, provided at G with four wedges, two of which, *c c*, are cut so that if looked upon from the top a round hole shows itself, and through this hole the end of the screw which at this point, L, is plain, and has a neck turned in it, passes, with its head beneath the wedges and against the lower G. So soon as this is effected the wedges A B are pressed into their places, and these holding *c c* together, cause them to secure G by its neck; if, therefore, G be now caused to rise, the block D must rise with it, but the head of this screw rests on the solid block D, while its neck is just so long as to admit of this without itself being pressed against the wedges *c c*. G is a very fine cut screw which fits into a female screw cut in the frame of the head of the draw-bench; it is moved to any distance varying from the hundred-thousandth part of an inch (0·00001) and upwards by the wheel H, which receives a very minute motion from the pinion I by means of a lever fitting into the capstan head J. K was originally intended to be used to set or fix the screw G when it had been brought to its proper position, but it is not used; for, in fact, the cylinders wear away appreciably by the passage of the fillets, so that they require constantly to be brought nearer together to make up for this wear. With some species of gold the friction is so great that, although oil is used, the cylinders become so hot as to render the gold pasty: in such case a kind of welding takes place, which causes the tearing of the fillet. If this extreme point be not reached, as indeed it seldom is, the cylinders become of varying temperatures, and so great is the effect of this that in order to compensate for it, the upper cylinder has to be continually raised or depressed. The beds which carry the cylinders become

worn by the strain and fret, and require grinding out at intervals; therefore, to allow for the difference which this would make, screws N are provided, by which the cylinder in the lower bed can always be raised to its proper position. Men admire the beautiful productions of other minds; but it may be doubted whether a more admirable instrument for this purpose can be contrived. Surely, if ever there were a marvellous machine for assisting the coiner, it is this. Sir John Barton, who invented and directed the making of this machine, took into consideration every circumstance which could possibly arise, but he never saw practically the full advantage of his conception. At the present day the average work produced by this machine is as two to six compared with the trials recorded by Sir John Barton. It has become fashionable to smile at the draw-bench, but this is one of those productions which will outlive its detractors, at least so long as economy and perfection are points to be studied in coining. Foreign Mints are said to have found no advantage in the use of the draw-bench. It is to be regretted that they could not find a man with sufficient intelligence to use so accurate an instrument; it is surely not the fault of the sun if men cannot see it. Mr. J. Martin, of the Paris Mint, has recently made some very accurate experiments with the draw-bench, and has produced results every way in accordance with those obtained in the Royal Mint, and is convinced that the draw-bench may be considered as the coiner's right hand.

The fillets which pass between the draw-bench cylinders are cut into lengths of about 18 inches by the shears shown at X, in Fig. 11, and are then passed to the tryer, who by means of a hand press similar to, but more delicate than, that shown at Fig. 7, punches out one or two blanks from each length of 18 inches, and weighs it, or them, against a standard weight, and in accordance with his judgment passes the fillets to be cut by the boys or men at the machines. The tryer makes an allowance of 0·20 grain on the pound of blanks for the loss which afterwards occurs by annealing. The fillets, notwithstanding the draw-bench, cannot be brought to perfect accuracy, and to meet such variations as arise, a difference is made in two of the cutting-out punches by altering their diameters to such an extent that a blank cut by them from a standard fillet would vary in weight from a blank cut by a standard cutter from the same fillet. One cutting-out punch is altered so that a blank would be 0·125 grain heavier, and the other so that a blank would be 0·250 grain heavier. This admits of a fillet otherwise too thin being used; but if the fillet be found to err on the other side, it is passed once more either through the draw-bench, or through the mill at a spring pinch. The tryer must be, as he is, a peculiarly steady man, with a calm judgment and considerable energy, for upon him depends the accuracy of the whole process of coining; he has been known not unfrequently so to manage his work that upon 5,000,000 of sovereigns coined, he has been within one sovereign of the calculated value.

The fillets having been thrown by the tryer into the receptacles which indicate the particular cutting-out punches to which they are to be taken, are fetched by a man who wipes off the oil, and then carries them to the cutting-out room, where the fillets are cut into blanks and scissel. In this place it may be noticed that soap-suds cannot be used in the place of oil, because the soap could not be removed without washing,—a practical impossibility,—and would therefore remain, and add indefinitely to the weight of the gold, and thus open the door for peculation. The cutting-out presses used in the Royal Mint are very cumbersome, and when in operation are terribly noisy: it is therefore hoped that at no distant period they may be replaced by some of a far more elegant construction; but it is believed that under all circumstances it will be found wise to adhere to the plan of punching out a single blank at each descent of the punch. For bronze it is well to obtain five or more blanks at each blow, but the limit allowed by law on blanks of the precious metals would render this false economy. Fig. 13 represents one of the twelve cutting-out presses, which are all driven by the wheel A, provided with a series of cams on its outer rim; one of these cams, B, is in the act of striking the friction roller C, which is attached to, and forms part of, the lever D. D is fixed to an upright shaft E, which at F is cut with a screw thread working into a female screw fitted into the main shoulder of the press at G. If now the cam B strikes C, and throws it outwards, it causes the shaft E to take a part of a revolution, and in so doing the screw F makes it rise and carry with it the block H, which loses its circular motion from the effect of a plug fitting in its groove, and fixed in the guide I. The lower end of H carries the screwed cap J, which supports the cutting-out punch, so that when E rises it carries the cutting-out punch through just the same distance upwards that itself travels. The cutting-out punch is now ready for action, and is released by the continued revolution of the wheel A, as will be seen by the figure; but as it could not fall with sufficient force of itself, assistance is rendered by the pressure of the atmosphere, as will be seen by the following arrangement. The lever D is provided, near its junction with E, with a loop of iron travelling on a screw, so that it may be moved farther from, or nearer to, the centre of action, and thus admit of the increase of power. This loop of iron is represented by K, and is continued by a rod of iron across the upper part of the room and through a hole in the wall to a system of levers L, from which a rod is suspended, the lower end of which is connected with a piston working in the chamber M. The chamber M is a hermetically closed vessel secured to a stone firmly fixed in the floor. The piston works in this chamber, and is covered with about two inches of oil, which prevents the access of the atmosphere by leaks to any part beneath the piston. If the piston, therefore, be raised from the base of the chamber, a vacuum is produced in that portion from which the piston is removed, and consequently the atmosphere presses on the surface of the oil, which in its turn presses on the

piston, and carries it down; in its fall the piston pulls down the cutter, which has been raised; for the same blow which raises the cutter also raises the piston; therefore, when the cutter is raised the workman places the fillet N, from which blanks are to be cut, on the bolster, shown at O, and holds it firmly while the cutter descends and punches out a blank, which falls into the drawer P through the bolster. By the time that the down stroke of the cutting-out punch is complete, the wedge Q has entered a slit in the spring R, and strikes the spring, thus throwing the machine back, and preparing it to start when the cam B shall strike the friction roller C. The point at which Q shall strike R is determined by a screw near the left-hand T. The upright shaft E, which is partly hollow, terminates at a flat cogged wheel, and the upper part of F is made to pass into E; while at S is an arrangement which serves to detach or connect these pieces, that the cutter may upon occasion be used by the hand by means of the lever T. The

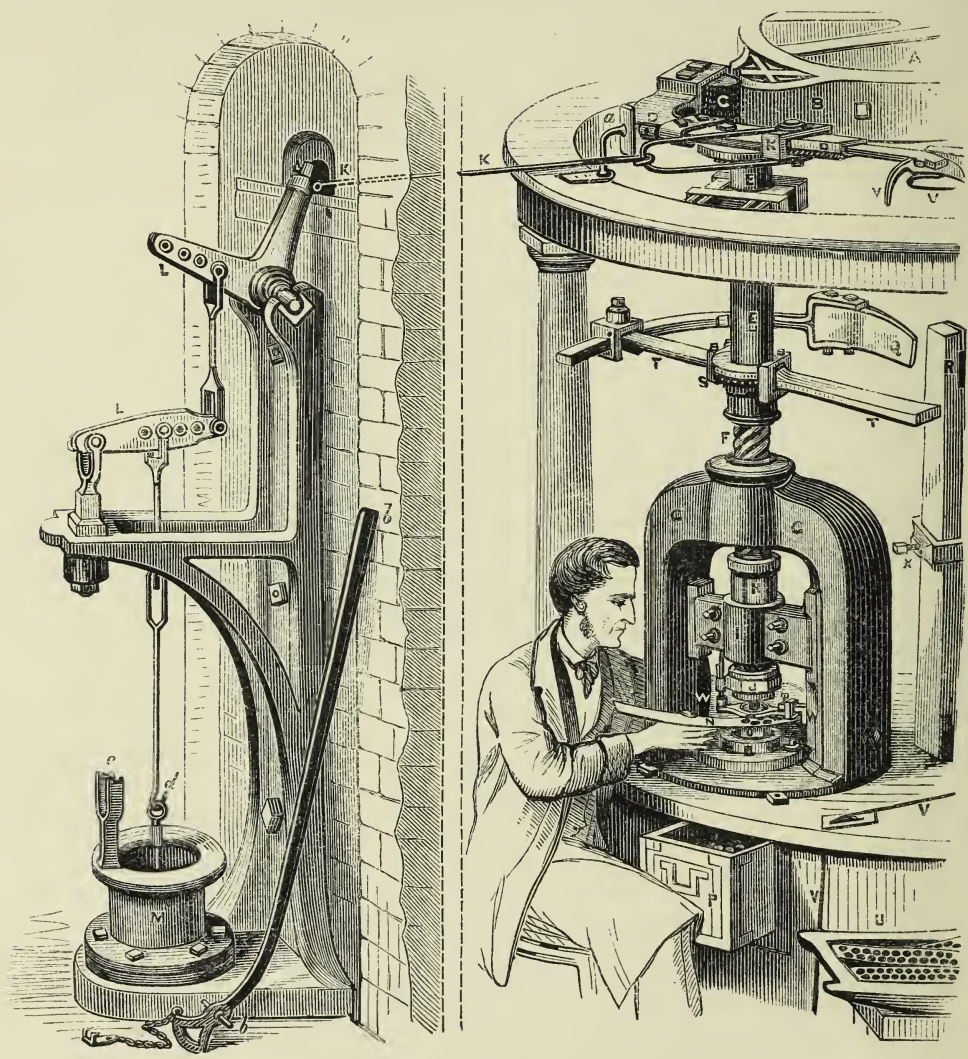


Fig. 13. CUTTING-OUT PRESS.

cutting-out punch, when it rises, carries with it the fillet, from which the blank has been punched, until the fillet comes against the guard W, which detaches it.

The fillets from which the blanks have been punched have the appearance of ribbons perforated with round holes, and are now called *scissel* (from the Latin *scindo*, to cut). These are thrown into a tray, U, from which they are taken at intervals and bound up by strips of scissel into bundles of 180 ounces (in the case of silver, 360 ounces), ready for the melting-pot. The cutting-out press is set at liberty to start by the workman pressing his foot on a lever in connection with the line and spring indicated by V; and so long as he keeps this lever down, the press is worked continuously, but when he releases it the spring catches the extreme end of D, and motion is arrested. The blanks which accumulate in the box P are collected at frequent intervals, and tested as to their accuracy, to see that the number in one pound is neither above nor below its proper weight. The blanks are also examined, to see that

their edges are smooth; if they be ragged, as may happen from the wear or fracture of the edge of either the cutter or bolster, a loss would be entailed in after processes which would cause the coin to be outside the prescribed limit, and to pass at an illegal weight into circulation, as the rough edges would be removed after the weighing of the blanks had been effected. The gauge, Fig. 8, is found of great service in detecting irregularities as to diameter and thickness, which would not be, and are not, detected by weight, for the weight may remain equal although both diameter and thickness may vary. All these points require considerable care on the part of those whose duty it is to attend to them; for the quality of a coinage is determined in this room; blanks which once leave it cannot be afterwards altered. The following operations, being purely mechanical, would be quite as well performed by automaton machines.

The future operations form undoubtedly the prettiest and most interesting part of the process of coining; nevertheless the processes already described constitute its most essential features. The blanks are weighed from this room in drafts of about 720 ounces, and placed in bags; each bag, therefore, contains four *journeys* of about 180 ounces each. The word *journey* is said to be derived from an old French word, but circumstances render it probable that this derivation has been applied by others than the original inventor of the word, for it manifestly was not used by the coiner of it to imply a "day's work." Authors do not hand down a time at which 720 ounces of silver became a journey, while 180 ounces of gold was also called by the same name. It must have taken far longer to coin 720 ounces of shillings or groats than to coin 180 ounces of sovereigns or half-sovereigns; hence the same word could never have been intended to mean "a day's work." Be this as it may, it is time that such names gave place to more appropriate and expressive terms. It is to be hoped that 500 ounces will become the standard maximum weight for bags of either of the precious metals; such a system would be the means of reducing the chance of error, it would have an actual meaning, and would be a convenient weight for a man to lift to and from a scale pan. When such a measure shall be convenient to the officers of the Bank of England, that institution will subserve to the interests of the Mint by adopting it.

The bags of blanks are carried forward to the room in which the weighing of the individual blanks is effected by Mr. Cotton's automaton weighing machines. Mr. Cotton's weighing machines form perhaps the most elegant and clever invention of modern times. They effect the process of weighing far more accurately than man can hope to do, and with extraordinary accuracy determine the weight of about twenty-three blanks per minute. Peculiarly admirable as are these machines, their perfection has been greatly increased by improvements suggested by Mr. Richard Pilcher, who has immediate charge of these machines in the Royal Mint. Mr. Pilcher, whose energy for invention is only equalled by his desire to give to the public the benefit of his inventions, has rendered these automaton balances serviceable to the Mint; whereas, as they left the hand of Mr. William Cotton, they were of great service to the Bank of England alone, where only two determinations, or in fact one determination is necessary; for it is only required to show that the coins issued by the Bank of England are not below the legal weight for circulation; whereas the Mint must guarantee that coins leave its works neither above nor below the limits fixed by law: hence the necessity for the incorporation of Mr. Pilcher's improvements with Mr. Cotton's beautiful invention.

The steel engraving exhibits a view of the automaton machine as used in the Royal Mint, where thirteen such machines are employed. For the purpose of illustration, the brass side of the machine has, in imagination, been torn away, as also has the top of the machine. To obtain the highly-finished drawing from which this engraving was made was a matter of no ordinary difficulty, but it was accomplished by the skill and assiduity of Mr. E. S. Gibson, to whom thanks are due, as well as to Mr. J. W. Lowry for the pains he has bestowed in executing the engraving.

The whole theory of this balance rests on the fact that the centre of gravity and the centre of action are in one line: either being disturbed, the balance is no longer equal. The machine gains its motion from a shaft fixed to the ceiling of the room. This shaft is driven by a small atmospheric engine, which communicates a more steady and even motion than would be communicated by the steam engine direct; for it is found that the oscillations arising from many causes are not indicated to so great an extent by the atmospheric engine, which is driven by the agency of the large chamber exhausted by the steam-engine—in fact, this chamber becomes a regulator or spring, which softens down the variations in the motion of the engine. The shaft supported by the ceiling conveys its motion to the weighing machine by a line A, which, passing over the friction wheels B, circulates round the stepped wheel C, which runs loose on the shaft communicating with E. The line A is maintained with sufficient rigidity by a weight D, which is suspended at the end of the lever carrying the friction wheels B. The weight D is just sufficient to ensure the continuous working of the machine, but is so light as to permit the line A to slip on C in the event of anything going wrong in the works of the balance. When the machine is to be set in motion, a kind of check is made (by screwing) to touch the face of the wheel C, and thus, by friction, C gives motion to the wheel E. This is an elegant mode of meeting a chance of accident, for in the event of the weight D proving to be too heavy, the extra pressure simply disconnects this check from the face of C, and so stops the machine. The machine having been set in motion, E, by communication with the wheels F, all of which are driven by it, causes the cam G to push forward the lever H, which, terminating at I, pushes forward the flattened continuation of I indicated by dotted lines, until it moves a blank placed in

the collar J, at the bottom of the hopper *h*, on to the scale-pan K, which, for the sake of clearness, is isolated, and will be seen behind the machine and under the extreme end of the hopper. So soon as the blank coin has been placed on the scale-pan K, the cam L raises a lever *n*, the office of which is to open the forceps M, and thus release the rod Q dependent from K upon the knife-edge R. While these forceps are open, the cam N, by its partial revolution, lifts the rod O, which is steadied in its motion by a pin rising from it, and entering the inverted arch *o*, while its lower extremity works into a socket on the table on which the whole frame of the machine stands. Towards the lower extremity of the rod O, it will be seen to branch out right and left, until each end passes through a kind of step in the rods Q, which is indicated by P. The office of this rod is to bring the beam, from which the rods Q are dependent, to a dead level, as well as to release both ends of the beam by one action; therefore, at the moment that the forceps M have released the one rod Q (the forceps are closed by a spring attached to the level *n*, and are intended to hold this rod Q while the blank is placed on K, because the friction caused by the placing the blank would have a tendency to push K from the knife-edge on which it is suspended, and thus blunt its delicate edge), the cam N, by the rod O, releases the rods Q, by rising from the steps P, and thus permits the beam to determine the weight of the blank placed on K. A close inspection of the steel engraving will show that the rods Q are suspended from and upon the knife-edges, R, of the beam S, which has a centre knife-edge T, by which the whole mass is supported and poised. The knife-edges are made to find their own planes or resting places, upon curved or hollow pieces of steel, thus securing the smallest point of contact with a certainty of the smallest amount of friction. In ordinary balances the substance to be weighed is placed in a pan, which is on the same level as the pan which contains the counterpoise; but in Mr. Cotton's balance, this condition is of no consequence, so that the counterpoise rests ultimately upon a point which is at the same distance from the centre of action as the point upon which the matter to be weighed rests. The counterpoise, U, is placed in a kind of cage, and any variation from this standard is at once indicated, even if it reach only to the thousandth part of a grain. By law, the weight of a coin may vary to a certain extent from a standard weight; the variation or latitude allowed is called *remedy*, from the Latin *ad remediam*, and in weighing, this remedy is taken advantage of by a contrivance much simplified by Mr. Pilcher. The weight of a sovereign is 123·274 grains, but it may by law be either 123·531 grains, or it may fall to 123·017 grains. Mr. Pilcher therefore reduced the counterpoise to the minimum allowed, thus avoiding the placing of a remedy-wire for the light side; and he then made the remedy-wire *q* (shown in the first enlarged portion on the left-hand side of the steel engraving), which is placed in the stand W, upon a peculiarly formed point indicated by V, so heavy that any blank which would not raise it must be within the remedy on the *heavy* side. In accordance with this arrangement, the continuation of the rod Q is terminated by a cage at V; so that if a blank be so *light* as to be unable to raise the counterpoise U until the stirrup comes in contact with the remedy, it is too light to make a legal coin. This fact being determined, the motion of the machine causes the cam X to bring back the rod I (indicated by dotted lines), that it may be ready when required to push forward another blank, and the forceps M to grasp the rod Q, while the cam Y permits the falling of the rod Z, which is nearly counterpoised by the ball *m* (the precise length of the rod being regulated by the screw *j*), until its finger *a* rests upon the indicator *b*. The depth to which *a* shall fall is determined by the step *l* (shown in the second enlarged portion, Q, in the steel engraving). This is of course fixed by the forceps, securing Q at the position indicated by the weight of the blank. The indicating finger *b* having come to rest, the continued motion of the machine causes the cam *c* to permit the shoot *d* to fall until one of its steps, *e*, comes into contact with the indicating finger, when the lower part of the shoot must be exactly over, and form part of one of the tubes *k*, which terminate in boxes labelled respectively "heavy," "light," "medium." The shoot having taken its position, the continued motion of the machine causes the cam G to induce the placing of another blank on the scale-pan K, and this blank, by advancing, pushes off the one just weighed, which falls into and through the shoot into the compartment reserved for it. Suppose the newly placed blank to be too heavy for forming a legal coin, the same operation goes on, but it now lifts not only the counterpoise, but causes the stirrup at V to lift the remedy weight *q*. This is a most delicate operation, for if a blow, however light, be given, it would cause unsteadiness in the beam. Mr. Pilcher, therefore, determined to make the carriage W, which supports the remedy-wire *q*, stand upon micrometer screws, by which the remedy-wire is made just to touch the stirrup, without pressure, while it also rests upon the most minute points, formed by cutting away every part of V which is not actually required—in fact, shelving it out. The scale-pan K is protected from draught by the lantern *f*, while the blanks are directed into the collar J by the guard *g*, as they slide down the hopper *h*, which at its centre is supported by an upright, *i*. The blocks *p* are the supports which hold all the machinery to the roof of the machine.

It is well to state that the beam in Mr. Cotton's balance is 8·90 inches in length, and that its weight is 288·41 troy grains.

Those blanks which are neither too light nor too heavy are called *medium*, and are weighed and put into bags for future issue as coins. The *light* are reserved for the melting-pot. The *heavy* blanks are reduced by means of a peculiar kind of file to the weight of medium, and are thus saved from being melted, so avoiding further loss to the Mint. This file was invented by Mr. Pilcher, who being the officer of this room considers his duty to be neglected if there

be any improvement capable of being made, but which is left undone; he never tires till the invention is complete and the machine made. Mr. Albert Barre, the distinguished engraver to the Paris Mint, declares this file to have surmounted all the difficulties he has met with in this part of the process. In his own words, it leaves the face of the blank untouched, and free to develop the work of the engraver, which no other file does, or can effect, because any metal which is *ploughed* out from the face of a blank, leaves a hole which is not filled up in coining. Fig. 14 is a representation of

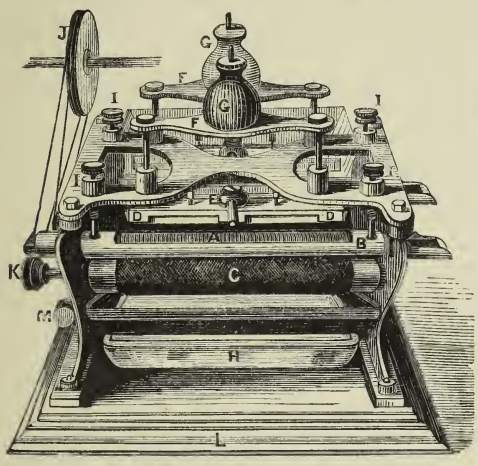


Fig. 14. FILING MACHINE.

this compact machine. The blanks A are placed in rouleaux in a tube B, which is open at top and at bottom; through the opening at the bottom the blanks rest their EDGES on the file C, which, as it revolves about 1,000 times per minute, files off metal from the edge of the blank. When all the tubes have been filled (each machine has two tubes), the rod D, which carries a triangular knife-edge, is released by the lever E, and the knife-edge rests on the upper edge of the blanks A, with the intention of offering resistance to their rotary motion, thus enabling the operator to remove much or little metal from their edge at pleasure by increasing the resistance offered by D by adding a weight G on to the gallery F. H is a glass dish into which the dust as it is removed from the edges of the blanks falls, thus ensuring a perfect separation of the dust from the blanks. The blanks in B are kept in their position by small blocks of ebony, which are secured by the thumb-screws I. Motion is given by the wheel J, which communicates with the pulley K by a cord or catgut. The whole machine stands on a block of mahogany, L, secured to a table of oak. M is a screw which is used to tighten the cords between J and K. Between C and H is a hopper of brass to catch flying particles of the precious metals. Each file reduces 250 sovereign blanks per minute.

The medium blanks are rung by boys to detect dumb or cracked ones, which are rejected for melting. Dumb or cracked blanks arise when bubbles of air are enclosed in the bars at the time of pouring the fluid metal into the moulds in the melting-house.

The medium blanks now determined to be good and fit for coining are weighed up in bags of about 180 ounces, and sent forward to the room in which is placed a machine which has to diminish the diameter of each blank by compressing its edges. This is called a *marking machine*, but such a name being obviously improper, it is preferred to call it the EDGE-COMPRESSOR. Up to 1861 the best machine for this purpose was that invented and patented by Messrs. R. Heaton and Sons, of the Mint, Birmingham; but in the early part of 1858 the subject of the diameter of blanks came under consideration as effecting the production of brockages. Mr. Pilcher was consulted, and proposed a machine, of which he gave an outline, which was submitted to the

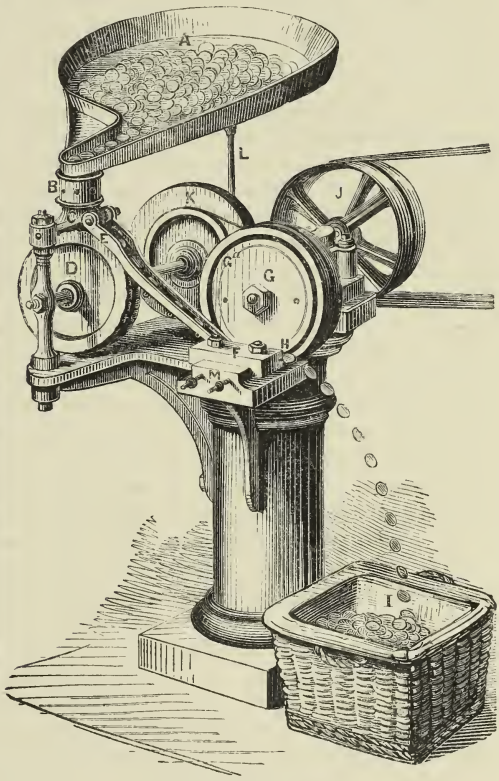
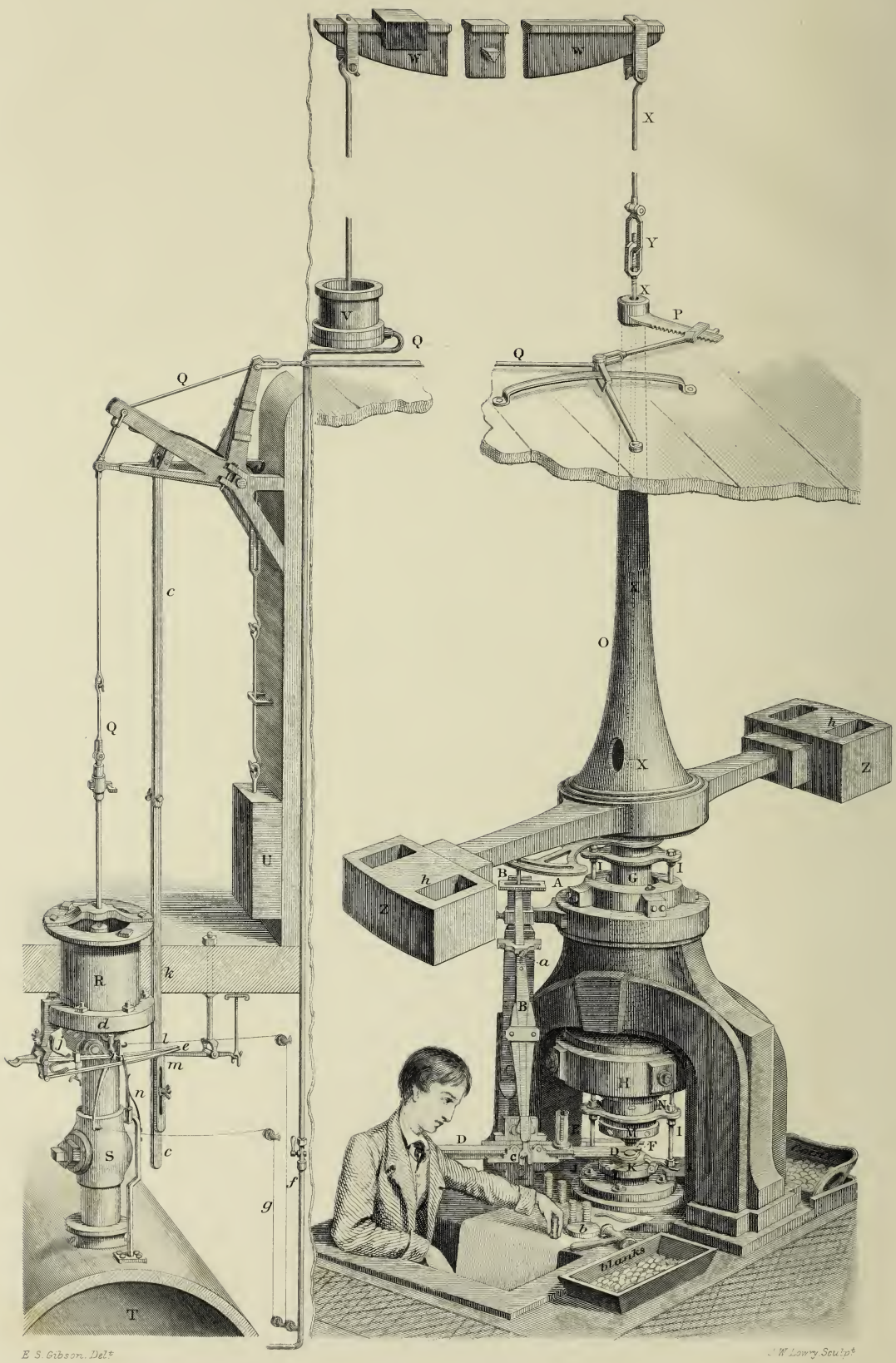


Fig. 15. MARKING MACHINE.

Master of the Mint on the 31st of March, 1858. This machine was to be fed from the top, but was abandoned because it did not meet the desired minimum of 1,000 pieces per minute. Mr. Pilcher, therefore, proposed to erect on the same spindle five revolving discs, and to face these five discs with as many cheeks. At a given time it was determined to manufacture a marking machine, and one of five which Mr. Pilcher proposed was to be made. It was preferred to ask Mr. Meredith Jones to assist in its manufacture. Mr. Jones had a design for a machine for this purpose, and it was arranged that as Mr. Jones made Mr. Pilcher's file he should make his own machine. Mr. Jones proposed, and Mr. Pilcher accepted, the following proposition. Mr. Pilcher was to retire from the machine, and in consideration

of his so retiring, and allowing the machine to be called Jones's marking machine, Mr. Jones was to give Mr. Pilcher one half of whatever sum might be paid by the Mint for the use of the machine. Fig. 15 represents Mr. Jones's machine. The blanks are placed in the hopper A, and fall by an incline into a tube B until they rest at C on a notched wheel D. As D revolves each of its notches carries away the bottom blank of the pile from the tube B, and leaves it to slide down the tube E till it reaches the block F. The block F is cut with a narrow groove which exactly corresponds with the groove G^a on the plate or disc G. The disc G revolves, and as the blank slides down and comes with some little impetus against the groove in the block F, the groove G^a catches it, and causes it to take two revolutions between the disc G and the block F, finally permitting its escape at H, when it falls into I, being now reduced in diameter and thicker on the edge, but its centre remaining as it was before. The machine is driven by J, the shaft of which carries a reduced rigger for the driving of K. The hopper is supported by the rod L. The distance between F and G represents the diameter of the blank after its edge is compressed, this distance being determined by the screws seen at M. Blanks of all diameters may be compressed at this machine if the block F and the plate or disc G be removed and replaced by others, neither operation taking many minutes. The edges of the blanks are compressed at the rate of 700 per minute. A boy of fourteen could work this perfectly well, but with more convenience if the hopper were replaced by such an one as is used to supply Mr. Cotton's weighing machine. The edge of the blank is compressed with a view to prepare it for the *crenating* to be given by the collar in the after process of conversion into a coin. The blanks are conveyed from the edge-compressor to the annealing room, where they are placed in rouleaux in iron boxes, 2,804 in each box, the tops of which are luted on with clay, and the boxes, then placed on iron carriages, are run into reverberatory furnaces, heated by Juckse's smoke-consuming apparatus, where they remain for an indefinite period. The furnaces are like that represented in the rolling room, for annealing the fillets in copper tubes. For annealing the blanks, these should be raised rapidly to a full red heat; and the time allowed for the operation should be from twenty to twenty-five minutes at the utmost. After the heating the boxes are withdrawn from the furnace and placed on the floor of the room to cool, till the blanks are assumed to have become of a low red or black heat, the point below which copper combines rapidly with oxygen; they are then opened. If the boxes be opened while the blanks are still of a full red heat, there is what is called too much loss by annealing, or, in other words, too much of the copper has become oxidised, and thus rendered soluble in the dilute sulphuric acid into which they are presently removed. The box having been opened, the blanks are turned out into a copper tray, and on this carried to a cistern of cold water, in which a colander stands; they are turned into this colander, and thus cooled rapidly. When cool they are taken in the colander to a leaden cistern of nearly boiling dilute sulphuric acid, in which they are placed, and remain for about three or four minutes. By means of this bath of sulphuric acid the surface of oxide of copper is removed; the gold on the surface from which the copper has been washed out is of a sponge-like form, and gives that beautiful bloom to the new coin. This process is called *blanching*, and is of great interest to the coiner, as it is here that his loss by coining takes place. The bars of gold sent to the coiner are found to be standard within certain limits, therefore the blanks produced from those bars must be of the same fineness; but by this process of blanching copper is removed, hence the standard, or the amount of pure gold contained in the blanks, is proportionably raised, and this tells on the million to an amazing extent. When the annealing is conducted for too long a period, the copper becomes oxidised to too great an extent during the time of annealing, for there is no atmosphere more capable of oxidising than that of one of these furnaces; it is for this reason that the heat should be gained rapidly, before this oxidising atmosphere shall have time to permeate the luting and attack the copper of the standard gold. At the trial of the pyx in 1861 the gold coined by Thomas Graham, Esq., the present Master, was found to be "4 grains on the pound too fine," that is to say, containing in 5,760 grains 5,284 grains of pure gold in the place of 5,280 grains, which it should have contained. This is well for the people, but it is bad for the Master of the Mint, because he has lost 4 grains of pure gold on each pound he has coined, which amounts to no less than £757·65870 in value upon every million of sovereigns coined. This loss may well be avoided, either by adding extra alloy to allow for this removal of copper, or, as would be far wiser, by abolishing the process of annealing the blanks, as was done in 1859, when more than a quarter of a million of sovereigns were coined from unannealed blanks obtained from brittle gold which was much harder than any ordinary gold to be met with. It must be remembered that the saving of bullion would leave a large margin for the increased destruction of dies, and in addition the coin would wear longer in circulation.

After about three minutes' boiling in dilute sulphuric acid, the blanks in their colander are washed under a stream of cold water, to remove the sulphate of copper and the sulphuric acid from their surfaces, otherwise these substances would deface the dies used for coining, as well as give the coin a dirty appearance. From the washing they are taken to a sieve of sawdust, A, Fig. 16, into which they are thrown to be dried by friction with the hand. The sawdust absorbs the water from their surface just as a piece of sponge would; but the surface is not all, for it is found that by the removal of the copper the gold on the face of the blank has been brought almost into the condition known as *frosted;* it is, in fact, to a small extent, honey-combed. The gold represents the comb, and the copper the honey, but as the copper is removed the water takes its place, and from these interstices has to be removed by heat. The blanks, having been



E S Gibson. Delt

J W Lowry Sculpt

BOULTON'S SCREW-COINING PRESS.

AS USED IN THE ROYAL MINT.

wiped in the sieve A, are put into the tray B, and from this they are shot into the colander oven C, which is closed, and then thrust into the heated chamber D, and twisted gently round and round at intervals during ten minutes. The blanks are then turned out into a sieve E, by which any particles of dust are separated; the blanks are finally, by the aid of the tray B, placed in a bag. The sawdust falls from the sieve A on to a plate of iron heated by the furnace F, by which it is dried, and becomes ready for another operation. The chamber D is heated by a small furnace beneath it.

The blanks, still warm, say about 160° Fahr., are taken to the coining press, which at the present time is in about the condition, as to efficiency, of what the old water-wheel is to the steam-engine; yet, as a relic of the past, it is a magnificent conception. It is perhaps the most interesting in its work of any of the coining machinery; its action is truly pleasing to watch, but one must feel that the totally deaf would enjoy the watching it at work more than would those who are endowed with the sense of hearing, because the noise of the presses would not disturb their thoughts. The noise is really painful. The blanks taken from the colander oven are each by a single blow converted into coins possessing the obverse and reverse impressions, as well as the *crenated* edge, which is one of the means employed to protect the coin from the peculations of the clippers, those enemies to coin of all ages and all countries, but whose business has departed, not so much from the crenated edge as from the better balances placed in the hands of almost every man—certainly within reach of every man. The crenated edge is known to be no protection against the plan called "sweating," and which is effected by shaking the new coins in bags, when perhaps an ounce of gold may be obtained from 1,000 new sovereigns. The sovereigns thus treated are passed, and the operator makes his profit, but the light gold is detected by the balance, not by the eye. This is not the place to discuss such a question, so that we pass on to a description of the instrument which is used to give the image and superscription to coins which are issued in accordance with the law.

The steel engraving illustrates Mr. Boulton's screw

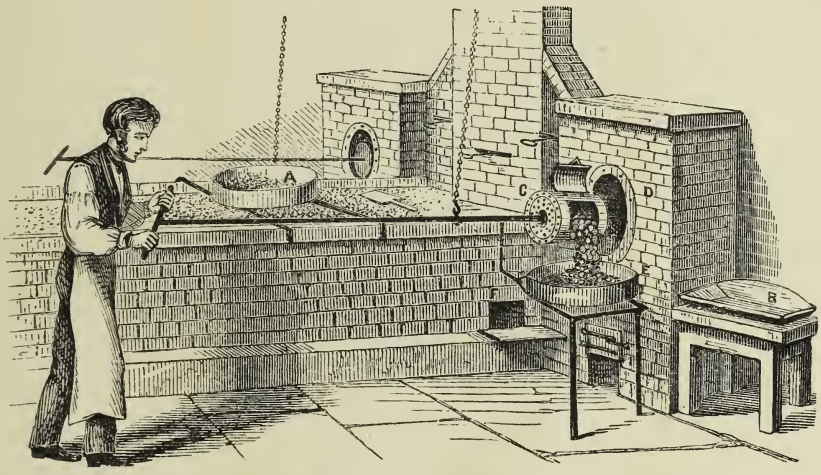


Fig. 16. DRYING ROOM.

coining press. The blank is laid by the automaton hand D on the lower die F; D retires, and the collar then rises and encloses the blank, while the upper die, fixed to the main screw of the press by the securing apparatus M, comes down with a blow estimated to be about forty tons, and striking the blank causes its particles to rearrange themselves and to assume the form given by the engraving on the dies and the crenated collar which surrounds them; in other words, the plain blank becomes by one blow a coin in every way complete. The following description will convey to the reader an explanation of the processes as they arise. The press having been set at rest, with the fullest space between the dies, has to be called up—that is to say, the upper die is raised from the lower die, and in this position the automaton hand D has conveyed a blank from the tube E to, and holds it over, the lower die F; upon the first motion of the press downwards, the eccentric wheel or cam A causes the lever B, which works on the pivot *a*, to withdraw D by the pin C. The lever B may be lengthened or shortened at pleasure by an arrangement against the lower B. The first motion towards the withdrawal of D, causes its finger or hand to open, and to release the blank, which falls upon the face of the lower die. The opening of the finger, or hand, is effected by a pin which works in a slit in the movable finger of D, near to C. The continuation of the motion which draws back D, causes the rods I, which are carried by the main screw G, to release the collar K, by the levers J. The collar K being thus relieved from downward pressure, rises by the elasticity of the springs L until it wholly encloses the blank which has been left on the lower die. The rods I pass through the shoulder of the frame of the press, and are destined for another service beside that just described; for the main screw G, which travels through a female screw fixed in the frame of the press (as may be seen by the dotted lines between G and H), thereby receives its power to rise or fall upon

each part of a revolution, whereas the upper die must strike the blank a blow just such as would be struck by a hammer, and without a twisting motion; therefore the twisting motion of G is lost just below H, where G fits into a cup suspended rigidly on, and prevented from twisting by, the rods I, as shown at N. To the lower part of the cup N is fastened M, which carries the upper die. So that just at the moment that the levers J have permitted the collar to enclose the blank, the upper die reaches the full force of its blow, and comes upon the blank. The force of the blow causes an instantaneous recoil of the screw G, which is assisted in its rise by a kind of balance which is just equal to its weight. The nature of this arrangement will be better understood by reference to the engraving, where the funnel-shaped tube O is seen to be traversed by a rod X, represented by dotted lines, and which terminates in the head of the screw G near the lowest X; the opening in the funnel being for the convenience of fixing this rod to G. At Y is a swivel where the twisting motion of X, given by G, is lost. X is connected at its upper end with a balanced beam W, the other end of which is in communication with the chamber V by a rod which carries a piston working in V. The chamber V is not wholly exhausted, but is in connection by a tube with the partially exhausted chamber T. The motive power of the press, that which brings down the die with force, is gained by the pressure of the atmosphere upon a piston in the cylinder R, and is conveyed to the press as follows:—The lever P is fixed firmly on to the trumpet-shaped tube O, and is connected by a series of rods, Q, with the piston in R, from which the tube S communicates with T. The large chamber T is kept in a constant state of partial exhaustion by the action of the steam engine, through a tube of considerable length, originally suggested by Mr. Newton, the officer in charge of this department. The boy who works the press starts it by first pulling a cord *f*, terminating in the box in which he sits: the cord *f*, by its spring *n*, releases the valve *d* at *i*, and permits it to act when required; he next pulls the cord *g*, which by its loose lever opens the valve *j*, through which the atmosphere passes freely across the bottom of the piston in the cylinder R into the tube S, and so into the partially exhausted chamber T; this would cause a rush of air through the valve *d*, but *d*, at the instant of its release by the line *f*, is closed by a spring. Atmospheric air expands instantly if the pressure be removed from it, so that immediately on the opening of the valve *j*, the air beneath the piston in R expands, and part of it entering the chamber T, produces an unequal pressure upon the upper and lower sides of the piston, and the result is that the piston is forced down by the weight of atmosphere it is unable to support. By the time that the piston has completed its stroke, the rod *c* has brought a button, which it carries on its farther side, and situated at *k*, down so low that it strikes the lever *l*, and closes the valve *j*, thus stopping the expansion of air below the piston, while the button *m* has at the same instant permitted the falling of the lever *e*, and the consequent opening of the valve *d*; when the recoil of the screw G takes place, the piston in its descent expels (by compression) the small amount of air remaining in the cylinder R through *d*, thus opening it so that air can rush in at this valve and permit the rising of the piston. The rising of the piston ensures the removal of the button at *k*, and so soon as *k* is removed, *l* is forced up by a spring at its farther end, and opens the valve *j*, thus giving the means of consecutive action to the press. If it be desired to stop the press, the boy loosens the line *f*, and so permits the spring *n* to keep the valve *d* permanently open. The boy before supplying blanks to the tube E, piles them on an iron block *b*, and flattens each blank in the pile by one or two blows of a hammer on the top of the pile. It has been conceived that coins are made of two discs of metal soldered together, and that the crenated edge is intended to hide the join. This notion has arisen from the occasional appearance of a cracked coin in circulation; the true explanation of the cracked coin being that at the time of pouring the fluid metal into the mould, an air bubble has been enclosed, and this air bubble has rent the fillet at the time of its being rolled; but the rent does not exhibit itself until the final annealing, when it is too late for its discovery: recently, however, it has become a custom to ring the coined gold before it goes into circulation, and thus to detect and stop such defective pieces. The origin of the crenated, commonly called the "milled," edge (thus giving the name of the instrument to the substance operated upon), was the desire to make any clipping of the coin easily noticeable. Many devices were used, but John Evelyn suggested the motto, *Decus et tutamen*,[1] and this was retained for some coins until 1854; but, without exception, the crenated edge is now produced, and it is really the best, as admitting of easier detection if counterfeited. The distinctive marking of the edge of coins is of very early date, and was effected by various species of hand labour, each in its turn easy of falsification. At length this was effected by machinery, until finally the coin was formed by striking the blank while enclosed in a collar. The use of the collar, and its first invention, is somewhat doubtful; but Mr. Hawkins appears to have established the fact of its having been used so early as William the Conqueror (*vide* "Ruding," vol. i. p. 158); but the earliest coin which gives a clear notion of the use of a collar, is the celebrated Petition Crown of Simon, which he coined for and presented to Charles II. Fig. 17 represents this highly-prized coin, one copy of which was sold a few months since for £275. This wood engraving is by Messrs. Cheshire and Dickenson, from a fac-simile drawing taken by Mr. E. S. Gibson; it is an exact copy of the coin in the Mint

(1) In Evelyn's "Discourse of Medals," 1697, p. 224, occurs the following passage:—"Mr. *Slingsby*, to whom I suggested the *Decus & Tutamen* out of a *Viniet* in *Cardinel de Richlieu's Greek Testament*, printed at the *Louvre*, hindering his intended Addition (*in armis*), which neither would have become the *impress*, nor stood gracefully in the circle."

collection. The coin is surrounded on its edge by a petition in raised letters, of which Fig. 18 is a facsimile. Mr. W. H. Barton thinks that this coin must have been struck while surrounded by a collar or it could not have been produced at all. This opinion induced a further search for the collar which was used, and which is believed to be in existence, and to have been seen by men now living. Mr. Barton suggests that the petition must have been engraved on a fillet of steel, which was then coiled up in a collar, as indicated by Fig. 19, and that the blank to be coined was then placed in the coiled

Fig. 17. PETITION CROWN.

fillet of steel. The coin having been struck, the fillet with the coin was knocked out from the collar, just as medals are now knocked out; and, once free, the fillet sprang off from the coin. This conjecture was so strongly confirmed by minute examination, that it may be interesting to represent the mode of operation by means of Fig. 19, where A is the engraved fillet coiled up and just ready to drop into the collar B; the opening C which is left, is copied from the petition on the coin, which shows the metal to have been forced through this part of the fillet; where its ends, which were cut to fit each other, did not quite meet. The

Fig. 18. PETITION CROWN.

head of this protruding part has been filed off, the file marks still remaining visible on this part of the edge of the coin. This fact renders Mr. Barton's conjecture almost a certainty. The coin weighs 517·10 grains; its average diameter is on the obverse 1·5784 inches, and on the reverse 1·5837 inches, both measures having been taken on the extreme edge.

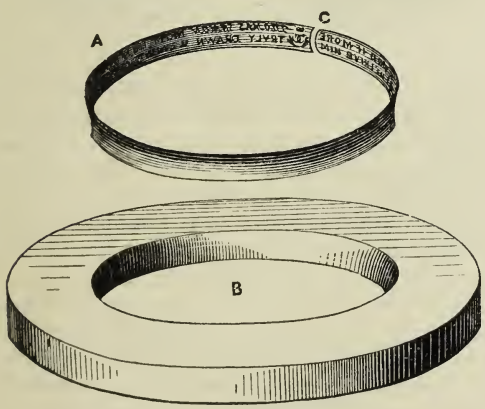


Fig. 19. FILLET AND COLLAR.

The petition is somewhat sunk and rounding inwards; if therefore it be measured from its lowest part, the centre of the edge of the coin, the diameter of the coin is 1·5741 inches, giving 0·0043 inch which must be worn away before the top of the letters of the petition can be touched in ordinary wear; thus the coin would circulate for centuries, and its petition still remain untouched. The coin being 0·0053 inch greater in diameter on its reverse than on its obverse side, admitted of its being more readily punched out from its collar, which was doubtless cut to admit of this design being carried out. The engraving on this coin is the cause of its great value, Simon having so perfectly carried out the idea that coins must represent sculpture, that the coin stands wholly unrivalled as a coin. It has led to the impression that such good artists are not to be found at this day as flourished then. The fact is that artists seek such employment as remunerates them for their study; and until their conditions of employment are satisfied we must abstain from the desire to see coins such as were produced in ages past, and which gave an honourable name to the country producing them. It may be hoped that this means of preserving the history of the age in which so much has been done may be continued. It is doubtless from this collar of Simon's that Sir Isaac Newton gained his idea for the collar which he is said to have invented. The collar of the present day leaves nothing to desire, for it gives such a distinctive mark to the edge of the coin that any mutilation must be detected; while forgers are unable to produce coins to imitate those struck in a collar, unless they use the same means, which would incur too great an expense.

The method of manufacturing the collar with the interior crenated circle is very simple:—A piece of flat, soft steel is bored with a hole of the required diameter,

and is fixed in a lathe so that it may be made to revolve rapidly at pleasure. While the partly-formed collar is revolving in the lathe, the slide-rest is made to place a kind of cogged wheel, carried on a rod of steel, into the hole which has been bored; by a screw in the slide-rest, the cogged wheel is brought down until it touches the inside of the partly-formed collar; at the moment of contact, the cogged wheel is turned round by the friction of the collar against it, and its continued pressure upon the inside of the collar causes the latter to receive an imprint from the cogged wheel. When the imprinting is complete, the collar is hardened, and it is then fit for use at the coining press. The system of manufacture is supposed to be the most perfect; but it is manifest that no two collars are produced of exactly the same internal diameter; hence the coin issuing from each collar of the same denomination, must, as it does, vary in diameter; but this is of small consequence, the difference being so minute that it is not detected unless by very accurate measurement; indeed, coins coming from the same collar must vary in size, since the collar wears away by use, to a certain extent. The diameter and consequent thickness of a coin is not determined by law, but by the convenience of the public to whom it is to be issued; hence the usual mode of arriving at the diameter of a coin is to make it of such a size that it will emit the most musical sound it is capable of. This rule was not sustained in the case of the small florin; hence, coupled with the omission of the *Dei Gratia*[1] in its superscription, the coin fell into disfavour. The following measurements, taken from a set of proof coins of the present reign, will convey an idea of the probable size of any coin of the realm; but from the reason before stated, a man need not be disappointed should he find the diameters differ from any he may examine by an accurate gauge. While stating the diameters (which never vary beyond a few thousandths of an inch), it is thought proper to give the legal weight and legal tender of each denomination of coin current in Great Britain:—

	Denomination of Coin.	Diameter.	Weight in Troy.		Legal Tender.
		Inchs.	Grains.	Oz.	To the value of—
Gold.	Sovereign	0·8680	123·2744	0·2568	The highest sum known.
	Half Sovereign	0·7622	61·6372	0·1284	
Silver.	Crown	1·5048	436·3636	0·9090	Forty shillings sterling.
	Half Crown	1·2714	218·1818	0·4545	
	Florin	1·1826	174·5454	0·3636	
	Shilling	0·9296	87·2727	0·1818	
	Sixpence	0·7648	43·6363	0·0909	
	Fourpence	0·6456	29·0909	0·0606	
	Threepence	0·6383	21·8181	0·4545	
	Maundy.				
	Fourpence	0·6957	29·0909	0·0605	
	Threepence	0·6383	21·8181	0·4545	
	Twopence	0·5294	14·5454	0·0303	
	Penny	0·4388	7·2727	0·0151	
Bronze. Copper.	Penny	1·3502	291·6666	0·6076	One shilling sterling.
	Halfpenny	1·1155	145·8333	0·3038	Sixpence ,,
	Farthing	0·8575	72·9166	0·1519	Sixpence ,,
	Half Farthing	0·6953	36·4583	0·0759	
	Penny	1·2000	145·8333	0·3038	One shilling ,,
	Halfpenny	1·0000	87·5000	0·1822	Sixpence ,,
	Farthing	0·8000	43·7500	0·0911	Sixpence ,,

The press for coining is said above to be still defective; one of its defects is the production of imperfect coins, of which Fig. 20 is a common type; it is produced by the failure of the automaton hand to place the blank exactly on the lower die, so that the collar, when it rises, fails to enclose it; hence, when the upper die descends to strike the blank, only that part of it which is over the die is impressed, the collar being forced down by the pressure of the

Fig. 20. BROCKAGE.

other part of the blank on its upper surface. On other occasions the automaton hand drops its blank too early, or fails to bring it forward at all; and on either of these occurrences, the dies come forcibly together, and disfigure each other, so that the next coin which is produced carries with it on each side a faint impression of both dies as well as its proper impression. This could never happen if the levers which carry the weights Z on the screw of the press performed actually the whole of the functions for which they are designed. Fig. 21 is a repre-

Fig. 21. BROCKAGE.

sentation of an imperfect half-crown which had been submitted twice to the process of coining, and by oversight passed into circulation in 1818. It was taken in change by Mr. R. A. Hill, in July, 1861; it is much worn, but on each side may be clearly traced the impressions of the obverse and of the reverse, such singular effects being produced where the crown of the reverse fits so neatly on to the back of the head of his Majesty, and where on the obverse the shield displaces his Majesty's face. This could hardly have been an accidental occurrence; it would seem that the workman of the press must have struck the coin properly, and then taken some pains to fit it into a larger collar and give it a second blow. If the collars were all of precisely the same size such would be impossible; but there are sufficient variations in the size of the collars to admit of this explanation. Some of these accidental productions have been called by ignorant writers *incused coins*, and conjectural histories of them have been published; when, in fact, their history

(1) *Dei Gratia* was also omitted on some of the coins of George I.

is simply this :—it so chanced that the coin remained upon the upper die and gave its lower side impression to the upper side of the next blank which was coined. This is no uncommon occurrence, and the effect of it would be that such a coin would have the same device on each side; but of course one would present the design in relief and the other in intaglio.

As the coined money issues from the press it is collected in trays and examined; all imperfect coins, curiously called "brockages," are picked out, and the good coins weighed into drafts of 701 sovereigns, equal in weight to about 180 ounces, and sent up to the Mint Office, where they undergo what is called *pyxing*, which is simply the selecting from each bag a pound weight, from which two coins are taken; each coin is weighed and its weight recorded. Of these coins one is placed in the hands of the assayer to determine its value as to per centage of gold, and the other is placed in a sealed packet, which is placed in the *pyx* for the trial of the pyx at Westminster—an ancient process now useless, because every man can detect by assay any deterioration of the coin. These particulars having been taken, the coin is in due course delivered to the officers of the Bank of England, who conduct it in amounts of about £140,000 to the Bank in a waggon.

The law enacts that 20 lbs. weight troy of standard or crown gold shall be made into 934·50 sovereigns, which gives the means of determining the theoretical weight of one sovereign; for if the 20 lbs. troy weight produce 934·50 coins, it is only necessary to divide by that number the number of grains in 20 lbs. troy, and the quotient will represent the weight of a single sovereign, viz., 123·2744783306581059 troy grains;[1] therefore the journey, as it is called, should weigh 180·0321027287319422 15 troy ounces, since it contains 701 sovereigns; and by the same rule a million of sovereigns weighs 256821·829855377 troy ounces, equal to about 7·8618 tons avoirdupois.

The coinage of silver is precisely the same in every detail as the coinage of gold; but there are one or two points that require to be dwelt upon. Weight for weight silver is more bulky than gold, and is coined in larger quantities; hence it has become important to expedite its coining by every means. Thus, in the process of annealing, it is simply placed unprotected, except by a lid of iron, upon an iron truck, and run into the annealing furnaces, from which, after twenty minutes, it is withdrawn and plunged at once into cold water. In the annealing of the silver blanks it is important to have the copper of the alloyed metal removed from their surface; this is effected by annealing the blanks for from seven to ten minutes in open pans, when the copper becomes oxidised, and is removed by the process of blanching, described under gold.

In annealing the precious metals, it is intended to use large retorts of Stourbridge clay instead of the naked flame, as is the present practice. The advantage of using retorts will be the protection they will afford to the substances to be annealed, and the uniform temperature at which they may be kept for any required time.

The coinage of bronze is somewhat new, that is to say, it has after centuries been re-introduced; and as little is known respecting it, it will be well to consider one or two circumstances connected with its coinage. The dimensions of the bars are given above; those measurements were determined after much troublesome experimenting; and the bars are found to be capable of producing the best blanks, as regards equality of weight one for another, with the least labour; in proof of which may be mentioned their adoption by Messrs. Heaton and Sons, of the Mint, Birmingham, whose experience is immense; that eminent firm having conducted a portion of the British bronze coinage, and the greater part of the present French coinage; the execution of the Italian coinage being still in their hands. The bars have also been adopted by another firm of less note as coiners. In the rolling of bronze there are some singular facts to be noted; for instance, the finding the same metal at one time ductile, and at another absolutely brittle; yet if the bronze has been properly melted, with due precaution to avoid the access of atmospheric oxygen, it is uniformly malleable and ductile, and may be rolled from such bars as described without once annealing. It is sometimes preferred not to use the knowledge gained, and then complications commence. The following mode of operating will meet all cases:—The bars may be rolled down to half their thickness, and then will anneal perfectly well in an open furnace on an iron truck. The heating should be conducted rapidly, and when the fillets get to a full red heat they should be withdrawn, and thrown out singly on the floor, and allowed to remain till perfectly cold. Should any bars be annealed in the rough state, they must be kept away from water. Two or three drops of water thrown upon the end of a bar when red-hot, cause it to become perfectly rotten throughout, and on any pressure it will fall to pieces like gingerbread; yet if the bars be partly rolled to a certain proportion of their thickness, they may be plunged at once into cold water without damaging them for work. After annealing, it is well to blanch the fillets in diluted sulphuric acid, containing one per cent. of the ordinary commercial acid. It is well to save time by blanching two or three tons at a time; but a few minutes effect all that is required, that is, the separation of the film of oxide from the surface. The film is then removed by a mop made of rag or cotton waste; with little labour a few boys may clean many tons in a day. Fillets which have been blanched produce clean and bright blanks. The blanks require somewhat different treatment. It is better to anneal them in copper

(1) Since the coins of a people must represent food in proportion as they are of specific weight, it is to be regretted that the law does not fix the weight (with a remedy) of the individual sovereign, instead of fixing the number of coins in 20 lbs. weight, and giving a remedy of 12 grains on the pound troy. Irrespective of law the practice in the Royal Mint is to apportion the estimated amount of remedy (or latitude for error) to each coin; but in America the pound weight alone is studied; hence the individual coins vary so considerably in weight that it pays as a commercial speculation to select the heavy coins, and to sell them as bullion; thus leaving the light coins in circulation, to the dishonour of the nation, because if a man take 1,000 American gold coins to the Bank of England they are not received at their nominal value, but as bullion, hence the loss becomes personal; and so the coins of America cannot, and do not, stand on a par with those of England.

tubes. The bottom of the tube should be covered to about an inch with charcoal dust, then the tube filled with blanks, which should be covered for about an inch with charcoal dust, and the top then put on to the tube. The annealing should not occupy more than thirty-six minutes; the highest temperature should be that at which the tube looks a full reddish white, and this should be gained as rapidly as possible. The tube, after removal from the furnace, should be allowed to remain at rest till perfectly cold. The charcoal is intended to combine with the oxygen, which would otherwise combine with the metals of the bronze during the heating and the cooling of the blanks in the copper tubes. Having regard to the production of perfect coins, the blanks should be cooled in an atmosphere of ordinary coal gas, by which every particle of oxygen is prevented from access, and a great part of the oxides already existing in the alloy reduced by the combination of their oxygen with the hydrogen of the coal gas, thus leaving the blanks somewhat porous, and comparatively soft, so that when coined the metal wholly fills the work on the dies, and the coin is produced with a good protecting edge. Bronze consisting of 95 of copper, 4 tin, and 1 zinc in 100 parts, may be coined to great perfection if the blanks be cooled in coal gas after annealing: whereas bronze of a far softer nature cannot be made to fill the work of the dies satisfactorily by any other method yet known, unless the engraving on the dies be very shallow. The British bronze is composed of 95 copper, 4 tin, and 1 of zinc in 100. The British bronze coins have what is considered to be an innovation[1] in the inscription in the repetition of the T, which is simply the classical mode of expressing in the abbreviated word the plurality of the possessions which together form Great Britain; it is equivalent to MS., which is the abbreviation for manuscript, while MSS. represents the word manuscripts; so BRITT. represents the cluster of islands or possessions called Great Britain. Copper or bronze money are equally tokens, it is therefore well to reduce such tokens to as low a weight as is consistent with the rigidity of the coin.

Coining cannot be conducted without dies; it is therefore well to add the processes of their manufacture. Experience alone can indicate the proper steel to be used, so that it is useless to attempt a description. But the form of the steel is a matter upon which die-makers differ; some use square bars of steel, and cut off pieces, which are forged into the proper form for dies; but the more experienced die-makers use round bars of steel which are cut by a tool somewhat of the shape of the bar, so that when the tool is struck every part of its edge begins to cut. The tool is so shaped as to leave the end of the bar from which the piece has been cut quite square, so that it may form the bottom for the next piece cut off. The piece of steel thus cut off is taken to a lathe, where its upper end is turned somewhat into the form of the top of a sugar-loaf; the depth of this form being determined by the style of work to be impressed upon the steel when it is to be formed into a die. For the original matrix the piece of steel is turned to a flat end, and is usually strengthened by driving a ring of iron carefully welded on to it: although some prefer to simply shrink on a ring of iron, the more experienced prefer welding, because that which is shrunk on is never so solid, and is apt to enclose air bubbles, which prevent the mass becoming one, thus permitting an undue yield in one spot when pressure is applied. In the making of a matrix, the steel is softened to different extents by different engravers, but all soften more or less. The steel having been softened, the engraver cuts with a kind of hand chisel, by a motion of the wrist, such design as may be required, and after many months of work produces a finished matrix, from which he requires to produce many copies, because this one matrix would itself soon wear out, and by frequent use would be more exposed to risk. It is, therefore, hardened to admit of its being submitted to such pressure from another piece of steel as to impart its design to that steel without itself being distorted by the pressure. For this purpose the matrix is fitted with a ring of iron round its upper part, which, when fitted on gives the engraved part the appearance of being the bottom of a cup; this cup is filled with a paste made of beer grounds and fine charcoal dust, or, better still, with that small charcoal which is found behind the flue of the forge, a kind of soot produced by the spent sparks which fly upwards, and which is so much in request by the file-makers. Thus protected, the matrix should be placed in the naked fire, wholly enclosed with fuel, and heated as rapidly as possible, keeping it constantly turned round and round, so as to ensure each particle of its mass being equally heated; a quarter of an hour should be long enough to produce the necessary temperature. It must be borne in mind that the great principle is to avoid the decarbonisation of the steel, therefore the less time that is occupied the better. The temperature of the matrix should be that rich and peculiar full red which for a few seconds is visible before white heat supervenes, for a white heat once gained causes the steel to scale off, and renders the matrix partially worthless. This peculiar temperature once gained, the matrix must be permitted to remain for three minutes in the fire without any blast. If it should get too hot it must be cooled by adding exhausted fuel from the hearth. At the end of three minutes' quiescent heating it may be assumed that the centre of the matrix has become of the same temperature as its outer particles; it is then taken quickly from the furnace and placed in a kind of colander, so that water may wholly envelop it, and yet flow freely past it while its under surface is wholly exposed. The matrix C is placed in the colander D, Fig. 22, bottom upwards, and is then brought immediately under the pipe dependent from a kind of funnel A, which should hold at least a hundred gallons of cold water; the bottom of the pipe must be secured by a plug of wood B, capable of being knocked out instantaneously. This is the most

(1) The objection to BRITT. on the ground of its being an innovation is singular, as this word occurs on the shillings of George III., coined in 1816.

important process in the hardening of the matrix, and requires great coolness with great rapidity of motion. The matrix being held in the colander about half an inch above a large surface of water E, and immediately under the centre of the plugged pipe from the funnel, the plug is knocked out from the pipe, and the water falls in a continuous stream wholly unbroken until it strikes the very centre of the base of the matrix, thus securing the commencement of the process of hardening FROM THE CENTRE. So soon as this first shock of the flowing water has been effected the matrix must be sunk into the vessel of water below, until it is uniformly covered to the depth of half an inch, and must be held there until the whole of the water from

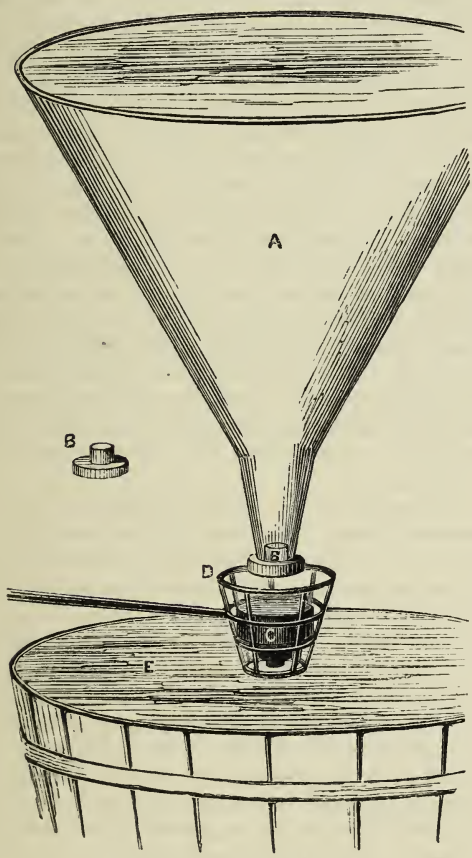


Fig. 22. DIE HARDENING.

the funnel has run out; then the matrix must be sunk to the bottom of the vessel of water, and allowed to remain till absolutely cold. If it be removed before it be cooled throughout, there is great danger of a crack on its surface being produced by the expansion from within. The plug is preferred to a tap in the pipe from which the water is to flow, because the turning of a tap gives a motion to the water, which causes it to fall in a hollow stream, and thus obviates the very effect which it is desired to produce. This process has been followed for thirty years, and during that time the manufacturer who uses it has never met with any accident, nor has he found any failure. It is regretted that his name may not be inserted here; suffice it to say that he is one of the most eminent engravers and die-makers in Europe. It is believed that all die-makers, after the hardening, proceed as follows:—Remove the paste of charcoal from the face of the matrix, and then clean the face of the die with hydrochloric acid. After this it is tempered, that is to say, it is raised to a temperature which somewhat relaxes the rigidity of its particles; this is commonly judged of by the COLOUR which the face of the matrix assumes; but since no two men are likely to distinguish the same tint, or no one man can actually judge unerringly, it is wise to adopt another standard; the one most preferred is to temper the matrix until the engraver can make a good graver bite while the die is hot. The tempered die may be cooled by plunging it either into oil or into water as soon as the tempering has reached the desired point. If at this instant the tempering cease, when the die is dead cold the graver will no longer touch the steel, which is now just so hard as to resist a blow without fracture. It is now polished, and is then fit for use, that is to say, is fit for the multiplication of dies from itself.

The multiplication consists in the taking a set of punches, each punch being an exact copy of the matrix. The steel, having been formed into masses with sugar-loaf tops in accordance with the depth of the engraving, is ready to receive the impression from the matrix, just as hot sealing-wax is ready to receive the impression from a signet. The matrix is placed beneath a press, and on its face is placed the sugar-loaf end of the annealed mass of steel; a very light blow is given by the press so as to obtain simply the sinking of the first or top portion of the cone, for if a violent blow be given at this stage it is manifest that a large mass of steel is forced into a smaller space; in other words, the particles of steel which formed the cone are pressed into a dense mass on the surface of the intended punch, and prepare a crack, which by-and-by develops itself. After this light blow, the partly-formed punch is placed in a covered pot filled with charcoal, and heated in a furnace just the same as was described for the hardening of the matrix, bearing in mind that it is the cooling, not the heating, which softens the steel. So soon as the heating has been raised to the point before indicated, the pot containing the punch is removed, and bedded in hot ashes, and then left to cool gradually, and as slowly as possible; it should be forty hours before it becomes cold. When cold it is cleaned, and receives a second very light blow under the press, and is examined, afterwards receiving a third very light blow, and is then a second time annealed, &c. The number of blows required to bring out to perfection on the punch the work on the matrix, depends entirely upon the size of the matrix and the depth of the work engraved upon it. For these reasons, no accurate instructions can be given; but for all cases light blows should be made, because all metals mould more readily under a kind of persuasion. There is little doubt but that certain stages of die manufacture would be rendered more effective if more reasonable treatment were employed. It has yet to be demonstrated that

carbon-steel is the best metal that can be employed, for it seems more than probable that some alloys would render a metal which would possess within itself more of the properties which are necessary for the perfecting a die, and for its duration when in use. For the elimination of such an alloy we must wait the time when a few experiments will demonstrate the applicability of such an alloy as is here alluded to. From the punch is obtained, by processes which should be in every way similar, a series of dies for the use of the coining press. Each die from the punch is examined, and has the figures for the date impressed upon it before it is hardened.. The dies are of two kinds, one C, Fig. 23, with a long neck, upon which the collar B fits freely, and the second with a short neck, so that the face of the die just enters the collar sufficiently to meet and compress the blank. Fig. 23 demonstrates these two

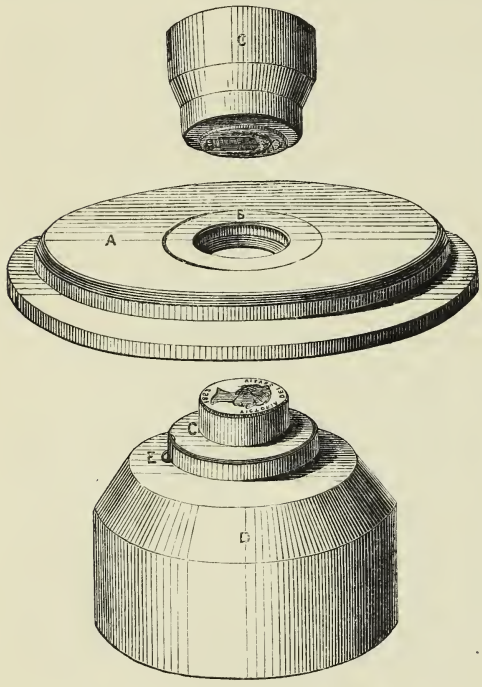


Fig. 23. COINING DIES AND COLLAR.

species, and the collar, showing the crenated interior circle which gives the crenated edge to the finished coin.

The long-necked die is fitted into a bolster D, as shown in Fig. 23, and is prevented from shifting its position in the bolster by a plug of iron indicated at E. The bolster with its die is secured in a kind of dish beneath the screw of the press by a series of screws, which admit of adjusting the bolster so that the die it carries shall be placed immediately beneath the upper die, which is carried on the main screw G of the press.

It would appear that the Royal Mint sustains less loss than any other mint by the coining of gold and silver. If allowance be made for the sale of the sweep or dust which results from a coinage, the total loss, inclusive of every operation in coining, is so small that it may be passed without notice : in fact there is a minute increase of weight from traces of oil which are left on the fillets to enable them to pass through the cylinders of the draw-bench ; but by melting there seems to be a loss of metal which reaches about £100 per million coined, but such a loss is wholly explained by the refining, which takes place by the removal of copper from oxidation ; although this is minute, still it is enough to explain the loss which arises. If the assays be closely watched there can be no loss, for the trial of the pyx invariably shows the gold coin to err on the side of purity ; so that if the Master of the Mint should determine to issue gold of exact standard, and refuse to avail himself of the latitude allowed, he may fairly cover every source of loss, and coin without waste of metal. Each grain that is found in excess of the standard upon the pound weight of gold, causes a loss of about £180 upon each million coined. The moneyers asserted that they sustained a loss of £700 for each million coined ; this was exclusive of melting. It has never been believed to have been a truthful statement, nor has the loss by coining alone ever reached so high an amount, although so large a sum as £373 per million would seem to have been determined by some careful experimenters as the necessary loss. Where the gold went to was not stated by these experimenters ; but supposing such a loss to accrue, it is manifest that the floors of a mint must be paved to many inches in thickness with gold, for it is an established fact that matter once existent cannot be annihilated ; but even with the data established in the Royal Mint it would seem that foreign mints still maintain a considerable loss, which must result from peculation.

The foregoing is not wholly demonstrative of the processes of coining as conducted in the Royal Mint, but is an accurate outline of the best developed plans ; yet such an account would be incomplete without an epitome of the ancient custom of the trial of the pyx. The most recent trial took place on the 17th of July, 1861, when the Lord Chancellor Westbury presided in the absence of the Queen, whom he represented as though she were personally present. Nine o'clock in the morning was the time fixed for the trial, but some delay was caused by the inability to open the pyx chamber in Westminster Abbey, owing to the rusting of the locks. The Lord Chancellor was supported by the following members of the most Honourable the Privy Council, Lord Granville, the Duke of Argyll, Sir Edward Ryan, and the Hon. Robert Lowe ; Lord Monteagle attending in his official capacity, and bringing the trial plates in sealed packages. The jury of twelve men selected by the Goldsmiths' Company were then sworn on oath. Lord Monteagle next declared that the trial plates were standard according to law, and that they were in the same state, and that the seals were in the same state, as when deposited in the pyx chamber. The Lord Chancellor then charged the jury, telling them of the prerogative of the crown, and that the sovereign has a right to issue money bearing her image and superscription, and that the people take such money in commerce because it is guaranteed of certain purity ; that this guarantee also ensures the

receiving of the money by foreign nations; and that these facts made the attesting of its purity a vital point, that all people might be assured by their verdict that the money issued is in accordance with the law, both as to weight and fineness. The Lord Chancellor then explained the laws relating to the coinage, and that the Master of the Mint, who was present, would, if their verdict were favourable, be discharged from further liabilities as to the coin he had made up to the 31st of December, 1860. After this the Lord Chancellor dwelt upon the antiquity of the trial of the pyx very briefly, and then explained that the word pyx is of Greek origin, and means box—the box in which is placed the money to be tested by the jury. He then explained the law as to the custody of the pyx and of its keys, and passed on to the latitude allowed for errors as to the standarding of the alloy, and for the remedy by weight for each pound of manufactured coin;[1] that there had been but one adverse verdict found by a jury at the trial of the pyx, and that the present verdict would doubtless be favourable to the Master of the Mint, who would then be discharged from further liabilities by royal letters patent. He then adjourned the jury to the Goldsmiths' Hall to make the necessary tests and trials of the coin, desiring that they should afterwards deliver their verdict to him, either at the House of Lords at six o'clock, or at his residence at eight o'clock. Lord Monteagle then handed the trial plates to the foreman of the jury. The trial plates are wide ribands of gold and of silver, about as thick as a florin, and indented on the edges. The face of each plate is stamped with the obverse impression of a sovereign die; and the date of its manufacture, with the proportion of its alloy, is engraved on each plate.

The jury having arrived at the Goldsmiths' Hall, proceeded to count and weigh the gold and silver moneys of Sir John Herschel, and of Thomas Graham, Esq.; they then selected a fixed number from the coins of each mastership for trial by assay, by a process similar to that described in the beginning of this article. The jury also tested the coined money by weight, but did not test any individual coin as to its weight, because the law only requires the coined money to be within the limits of weight allowed, supposing any fixed number of coins to be weighed against a standard pound. The limit, or remedy, is 12 grains on each pound weight troy of gold coin, or about 0·2568218 grain on each sovereign, and 24·00 grains on each pound weight troy of silver coin. After the assay the jury agreed upon a verdict, which was to the effect that the moneys of both masterships were found by them to be within the remedy, both as regards weight and fineness. This verdict was delivered at eight o'clock, P.M., at the Lord Chancellor's private residence. The Master of the Mint, with his deputy-master and other officers, was present during the trial. The total amount in the pyx at this trial was £36,417 10*s.* in gold moneys, and £807 4*s.* 3*d.* in silver moneys, and from these the jury selected a total of 60·616 ounces of gold and 71·018 ounces of silver for the assays.

(1) Specified by the Mint indenture, which is legalised by the Act of Parliament, 56 Geo. III., cap. 68, sec. ii.

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